



IMPERIAL BUREAU OF FRUIT PRODUCTION

TECHNICAL COMMUNICATION No. 7

VEGETATIVE PROPAGATION OF TROPICAL AND SUB-TROPICAL FRUITS

Compiled by

G. ST. CLAIR FEILDEN, B.A.

Drawings of Propagation Methods and Accompanying Descriptions by

R. J. GARNER, N.D.H., DIP. HORT. SCI.

East Malling Research Station

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The realization of the expediency of vegetative propagation in commercial orcharding is now so universal as to have passed beyond the need of argument. As Wester, perhaps its most fervent and practical advocate in respect of tropical fruits, remarks, "It is the cornerstone upon which rests modern fruit culture." But, however general the practice may be in temperate zones and however much those who dwell in warmer lands may approve the theory, only in recent years have serious attempts been made to study the vegetative propagation of tropical tree fruits, other than a few of such established commercial value as the avocado and the mango. Even in the case of the latter, which has been in cultivation in the East for countless centuries the cumbersome and restricted method of approach inarching is still in many countries the only method of asexual propagation used.

The English work on standardization of fruit tree rootstocks was still in 1926 comparatively little known to the Empire fruitgrower outside England, when the Empire Marketing Board realized its immense possibilities and entrusted Mr. Hatton with the task of briefly summarizing the results of his work and its bearing on fruit production throughout the Empire. The resulting article appeared in 1927 and was circulated to every Dominion, Crown Colony and Protectorate. It contained a questionnaire asking for information on the use of vegetative propagation methods in the cultivation of the fruits of the country concerned and of any particular advantages noted or difficulties encountered. Replies showed that technique varied immensely, that standardization of material had rarely, if ever, been attempted on a commercial scale, that its advantages were realized, but that knowledge of how best to achieve it was by no means common.

For the past twenty years, indeed, here and there throughout the tropics individual workers have been engaged, often only in time snatched from other pressing duties, in investigating ways and means by which quick and large scale vegetative propagation may be applied to the many fruits hitherto raised only from seed or in certain cases laboriously multiplied by marcotting or approach grafting. But even now the considerable results obtained are less widely known than is desirable, being published in bulletins and journals not always available to those whose work lies away from scientific libraries, and it has devolved on the Imperial Bureau of Fruit Production to collect the scattered information and issue it in the form of Technical Communications.

The first of these was published in 1932 and dealt with citrus. The present one concerns other important tropical and sub-tropical fruits and it is hoped that its information may prove useful both to the lone worker and to others engaged on this particular side of tropical agriculture.

Obviously much more still remains unpublished, and it is particularly asked that those who have worked on the vegetative propagation either of the fruit species included here or of any others of tropical and sub-tropical regions should write and give the Bureau the benefit of their experience. Results of rootstock trials are of especial interest.

The Bureau will gladly put workers in touch with experts on the methods advocated and will endeavour to provide further particulars on any technical points which are not entirely clear.

A further communication will deal with the vegetative propagation of perennial tropical and sub-tropical crops other than fruit, and any information will be welcome.

VEGETATIVE PROPAGATION OF TROPICAL AND SUB-TROPICAL FRUITS

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FOREWORD

By SIR GEOFFREY EVANS, C.I.E., M.A.,

Director of the Imperial College of Tropical Agriculture, Trinidad

It is with pleasure that I venture to write a brief foreword to this memoir of the Imperial Bureau of Fruit Production, as I consider that the fund of information collected therein will prove of singular value to workers in the tropics at the present juncture.

The use of vegetative propagation methods would appear to be one of the surest signs of advanced horticulture and has naturally reached its greatest developments in the temperate regions, probably because the question of improving quality in fruits has occupied the attention of numerous scientific workers for many generations and in many cases has years of tradition behind it. The tropics, and particularly the wet tropics, have lagged behind, partly because scientific workers have, until the last decade or so, been few and far between, and also because local markets for high quality fruit have been strictly limited. With the development of low temperature research, problems of transport and storage are being solved, with the result that the vast markets of the industrial areas of the temperate zone may now become opened up and it may be possible to place tropical fruits in these areas at a reasonable cost and with a minimum amount of loss through wastage. People travel about much more than they used to do, and, having once visited the tropics and tasted some of its delectable fruits, they demand to be supplied with them when they return to their homes. The most obvious example is the banana, which fifty years ago was a comparatively expensive delicacy outside the tropics but is now regarded as a regular article of diet in almost any town in Europe or North America. A more recent example is the grapefruit which has achieved an immense popularity within the last twenty-five years. Other tropical fruits are now beginning to be better known, such as the mango and even the pawpaw, whilst the avocado pear has a definite vogue, particularly in Northern America. Considerable progress in solving the transport problems of these fruits has been recorded in the past three or four years.

It is obvious that, as markets expand, the demand for standard varieties of high quality will arise, and every effort must be made to supply plants of the required type for the new orchards that will be planted. It is in this connexion that vegetative propagation methods are so important.

In the temperate, and to a great extent also in the sub-tropical, areas chance variations or mutations have been selected and have been preserved and accumulated by means of vegetative methods by skilled gardeners for many decades past. In the wet tropics by contrast many species of fruit are as yet hardly removed from the wild state, and for this state of affairs seedling reproduction is mainly responsible. The tropical horticulturist of the present day is trying to make up for lost time, and is endeavouring to compress into a few years processes that have taken the accumulated experience of generations in the temperate zones. His task would be a pretty hopeless one under the old conditions when knowledge diffused slowly from one worker to another. Nowadays much knowledge has been recorded and collated, but even so, as our experience at the Imperial College in Trinidad has shown, the technique of vegetative propagation remains very much a matter of trial and error. Under these conditions the work of the Imperial

Bureau of Fruit Production in summarizing and circulating the latest information from every part of the world is a most valuable contribution to the advancement of horticultural science in the tropics. It is particularly gratifying to note that a further memoir dealing with the vegetative propagation of perennial tropical and sub-tropical crops other than fruit will follow, because these crops, on account of their relatively low price compared with fruits, present peculiar difficulties. Rapid and cheap methods of propagation will, therefore, have to be developed, if it is to become possible to adopt improvements of this kind on a large scale.

The present memoir is a noteworthy contribution to the literature on this subject. The information that it has been found possible to collect appears to be most complete and the varieties of tropical crops dealt with is singularly impressive. The compilation of this standard work of reference obviously represents a vast amount of detailed labour and devoted study, and the compiler and the officers of the Bureau of Fruit Production are to be genuinely congratulated on the result.

G.E.

19th March, 1936.

Imperial College of Tropical Agriculture,
Trinidad, B.W.I.

METHODS OF VEGETATIVE PROPAGATION

In order to avoid ambiguity and to reduce explanation to a minimum, a description, frequently accompanied by an illustration, has been given at the beginning of the communication of each type of budding, grafting or other vegetative propagation method mentioned suitable for dicotyledonous plants. There should thus be no doubt as to what is meant when these terms are encountered in the text. Special modifications of a standard method to meet the needs of a particular fruit are described under that fruit.

Monocotyledons require treatment for which no general rules can be made, since it varies with each genus. Where plants of this nature are under discussion the methods are there described in full.

It should not be assumed that, because any given method of propagation is not mentioned for a particular tree, the method is unsuitable. The method will have been omitted because no records of it are available. It is more than probable, for instance, that the etiolation method of rooted shoot production and the modified Forkert method of budding may prove successful with a number of tree fruits on which they have not yet been tried. The possibility of the method of marcotting, however, has been taken for granted in most varieties and only in the event of any special information being available in connexion with any particular plant will reference be made to it.

The term "budding" implies shield budding unless otherwise qualified.

Where no specific rootstock is mentioned it is because information is not available. In such a case the same species as the scion can be surmised.

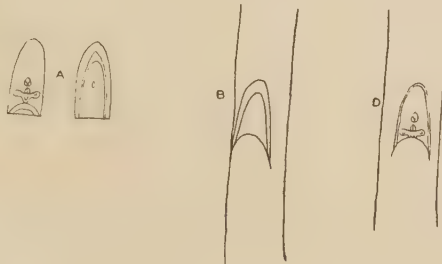
BUDDING.

Bud wood. Petioled and Unpetioled.

By *petioled* bud wood is here meant that wood of which the leaves can be cut off close to the bud at the time of budding, leaving a small projecting stub. By *unpetioled* bud wood is meant that bud wood from which the leaves must be cut off about two weeks before it is taken from the tree. This in due course will cause the petiole stubs to absciss, leaving a healed scar underneath which cannot serve as a point of entry for disease.

Chip Budding.

With deciduous trees the operation is normally carried out just before the stock begins active growth in the spring, using buds taken from dormant bud wood collected previously.



CHIP BUDDING

The scion is prepared by cutting from half to one inch above the bud, passing the knife downwards under the bud, just entering the wood, until the cut is about half an inch beyond the base of the bud, when the knife should be withdrawn. The bud (A) is removed by a second slanting cut which begins immediately below it and continues until it meets the lower extent of the first cut.

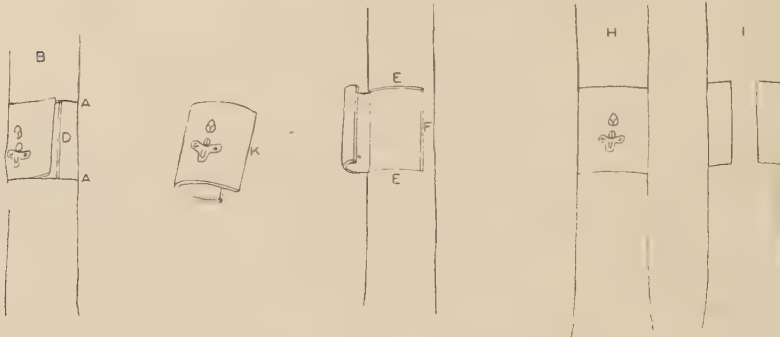
Similar cuts are made on the stock (B) to fit the bud. These cuts should be so made that the cambia of stock and scion are in contact on all sides or at least at the top end of the cuts and on one side. The bud (D) should be tied firmly and all cut surfaces should be sealed.

Flute Budding. Modified Patch Budding.

This is sometimes used when shield budding and similar methods fail to give satisfactory results.

For ease of manipulation the stock and scion should be of approximately the same size and age and should be in such a condition that the rind parts readily from the wood.

The scion bud is prepared by making two horizontal parallel cuts (A) encircling the bud-wood (B) through the rind down to the wood. This operation is facilitated by the use of a knife having two parallel blades. A vertical cut (D) connects the two horizontal cuts and enables the bud to be removed. If the horizontal length of the bud patch is more than sufficient to encircle some seven-eighths of the stock, it should be shortened by a vertical cut removing the required amount of surplus rind. This will avoid completely girdling the stock (ring budding) when fitting the bud patch, and, if the bud dies, the head of the stock will be saved.



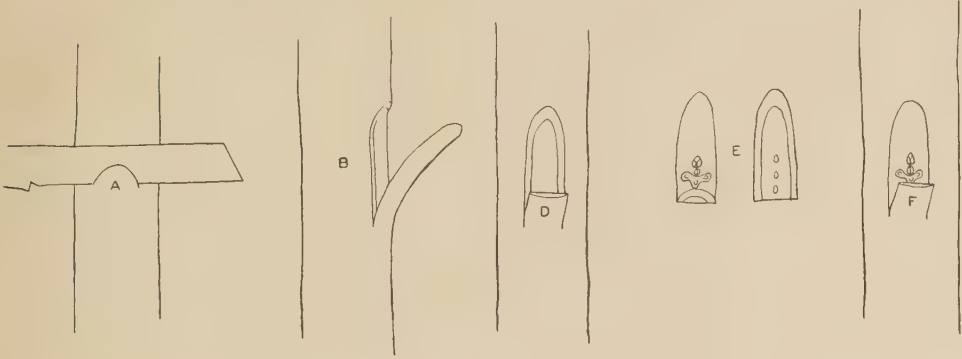
FLUTE OR MODIFIED PATCH

Similar horizontal cuts (E) are made almost completely round the stock and a vertical cut (F) enables the rind to be raised from the wood. The vertical edge (K) of the rind patch carrying the bud is placed against the corresponding cut edge (F) of the stock. The rind of the stock between the horizontal cuts is then peeled back until the bud patch fits the stock. The raised rind of the stock is removed by a vertical cut to coincide with the edge of the bud patch. Opposite sides of a budded stock are shown at (H) and (I). Tying completes the operation.

Forkert and Modified Forkert.

This latter method is the form of budding which has practically superseded all others in the Dutch tropical possessions. A transverse incision (A) is made in the bark of the stock as far as the cambium, and the bark is then peeled down to a depth of about an inch with a width of about one-third of an inch (B). The bark may peel in one or

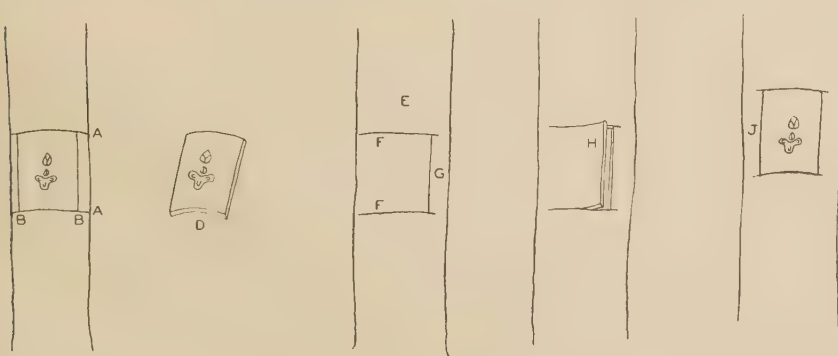
several strips. Two-thirds of the flap thus formed are cut off transversely (D). The bud (E) cut to fit the stripped portion is pushed under the remaining portion of the flap (F) and tied with raffia. In the ordinary Forkert method, which is now considered to be less satisfactory, the bark is cut instead of peeled. It is, therefore, less easy to judge whether the stock is in suitable condition for budding.



FORKERT METHOD

Patch Budding.

By the use of a knife having two parallel blades, cuts (A) are made horizontally around the bud wood through the rind above and below the selected bud. Two vertical cuts (B) made with a single blade connect the horizontal cuts, and the patch (D) containing the bud is removed. The stock (E) receives similar horizontal cuts (F) slightly longer than the width of the patch. A single vertical cut (G) enables the rind to be raised and peeled back (H) so that the bud may be placed in position. The stock rind is peeled back a distance equal to the width of the bud. A vertical cut (J) removes the surplus stock rind, and all exposed edges of stock rind and patch are in contact. Tying completes the operation. In some cases it appears to be an advantage to seal the exposed cut surfaces.



PATCH BUDDING

Ring Budding *see* Flute Budding,

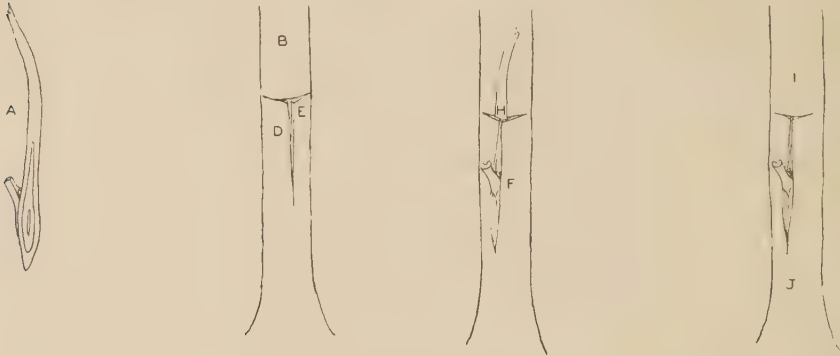
the difference being that in ring budding the stock is completely girdled.

Shield Budding.

This is one of the commonest methods of budding and is most easily employed where the portion of the stock to be budded is not more than two or three years old, or where the rind is not so thick as to cause manipulation difficulties.

Shield budding is normally carried out during the height of the growing season when the rind parts readily from the wood of the stock.

The scion buds are usually taken from shoots of the current season's growth where they exist in the axils of the leaves. The bud is removed from the bud wood by a shallow slicing cut which commences half to one inch below the bud (*see note*),



SHIELD BUDDING

passing under the bud and coming out well above it (A). If the knife blade be arrested before it quite attains the surface at the finish of the cut and the removal of the bud patch is completed by tearing, the patch will terminate in a long strip of rind which makes a convenient handle. It can be cut off after the bud is inserted (H). With some subjects the portion of wood underlying the bud may be removed from the bud shield before inserting the bud beneath the rind of the stock. The stock (B) is prepared by making a T shaped incision (D) through the rind down to the wood. The rind is raised (E) and the bud inserted (F).

NOTE.—If the inverted T is employed, the cut begins above the bud and passes in the reverse direction.

ETIOLATION METHOD.

This is essentially a form of layering. Young plants of the variety to be layered are set at an angle of 45 degrees in rows 5 feet apart. The distance between the rows is designed to allow for the future drawing up of enough soil from between the rows to cover the layer beds to a depth of 6 inches. The plants in the rows are spaced so that they will form a continuous line of shoots when laid down. When the plants are well established (an important point), they are pegged down flat in shallow trenches along the rows. With deciduous trees this is done in the dormant season. Immediately before bud break the whole plant is covered with fine soil to the depth of one or two inches only in the first instance and more earth is added as the shoots push up, until the bases of the shoots are covered to a depth of from 3-4 inches, the mound finally reaching a height of 6-8 inches around the stem. The lower part of the shoot is thus always kept in the dark and so becomes etiolated. In the case of many subjects this blanched portion will put out roots with more or less freedom according to the variety. At the end of the growing season the rooted shoots are removed and planted out, sufficient numbers being left on the parent plant to form future layers. Thus the bed once established becomes more or less permanent and a constant supply of young

plants can be obtained. This, briefly, is the method adopted in raising rootstocks of certain deciduous fruit trees at East Malling. It can, of course, equally well be applied to trees which it is desired to establish on their own roots.

With the evergreen trees of the tropics, which are seldom completely dormant, certain modifications have been found necessary. The technique is being very thoroughly investigated by the Agricultural Department of Malaya, and we are indebted to them for the trouble they have taken to supply us with much valuable information. They found that with evergreen trees the layered branches died back if covered with soil too early, but that, if the shoots were allowed to grow several inches before being earthed up, this did not occur. (At East Malling it is considered important that at no time should the portion of the shoot to be etiolated be exposed to light after growth has started.) In many cases rooting has been greatly assisted by binding a wire round the stem of the shoot near its junction with the parent plant. The wire is not adjusted tightly enough to injure the bark at the time, but as the shoot swells the wire slowly penetrates the bark without causing open wounds and provides a stimulus to root formation. Oppenheim (69), who used this wiring method with citrus in Palestine, says that with cuttings the roots, though they start above the callus, grow downwards between the bark and the wood and only become visible after penetrating the callus. In wire-bound shoots the roots grow directly through the bark above the ring. There appears to be considerable difficulty in establishing rooted shoots in bamboo pots. The bamboo joint is far from being an ideal receptacle but it is cheap and unbreakable and takes up little space in transit, and is, therefore, useful when plants have to be distributed to various parts of the country, and, of course, cheap distribution of economic plants is one of the important functions of many Agricultural Departments. Plants are more easily established in clay pots, probably owing to better aeration (53). Professor Cheesman of the Imperial College of Tropical Agriculture, who has kindly commented on the MS., suggests that the use of palm leaf or other cheap baskets such as are used in nursery work in the tropics might have the advantages of clay pots without their expense. Delayed etiolation is employed in what is known as the stooling method. This method is worth trying with tropical plants which do not respond to layering. In it the plants to be propagated are cut back to ground level and the fresh vigorous growth which should result is etiolated by heaping earth around it as it grows. At East Malling the earth is first drawn round the plants (apple stocks) when the new shoots are three or four inches long, further additions being made from time to time. The shoots should never be buried to more than half their length.

GRAFTING.

Grafting Wax.

The following recipe for grafting wax for use in the tropics is, by kind permission of the author, taken from Hawaii Agricultural Experiment Station Bulletin No. 59, 1929, "The Macadamia Nut in Hawaii", by W. T. Pope :—

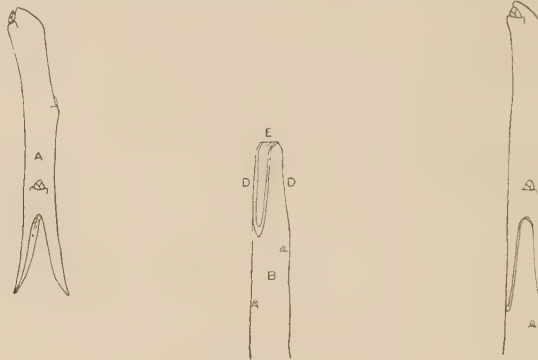
The materials required are by weight 1 part tallow, 8 parts beeswax and 4 parts resin. "Melt the tallow in a suitable iron kettle over a slow fire ; then add the beeswax. As soon as the mixture begins to boil add the resin gradually, stirring continuously until it melts. Continue the boiling for five minutes, then remove the kettle from the stove and pour the liquid through cheese cloth into a large container of cold water. When the mixture has thoroughly cooled, work it with the hands until it becomes tough and doughy. Thorough cooling is very important to prevent lump formation. Kneading may be difficult at first, but becomes comparatively easy after a few moments. To prevent the wax from adhering to the hands grease them slightly with tallow. As soon as the wax assumes a creamy, silken colour it may be worked into rolls about 2 inches in diameter and 5 inches in length, then wrapped in waxed paper. The wax is then ready for immediate use, or it may be stored for future use. If it hardens, knead in a very small amount of tallow."

Approach Graft, see Inarching.

Bark Graft, see TOPWORKING, Rind Graft.

Saddle Graft.

The stock and scion should be approximately the same size. The scion is prepared by cutting upwards through the rind and into the wood on opposite sides of the scion piece. The knife should penetrate more deeply into the wood as the cuts are lengthened and, before the knife is withdrawn, turn sharply towards the middle of the scion so that the middle portion may be removed and the scion (A) have the required saddle formation.



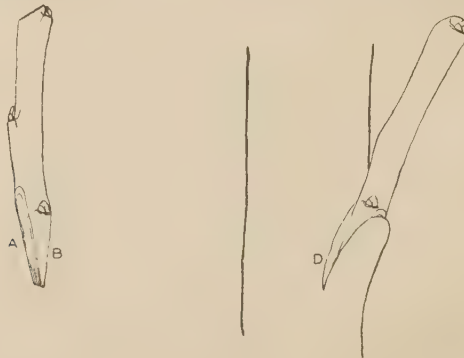
SADDLE GRAFT

The stock (B) is cut transversely and receives two upward cuts (D) on either side sufficiently deep to expose the cambia in such a position that they may match those in the saddle of the scion. The apex (E) of the stock is shaped to fit the saddle. Stock and scion are fitted together and firmly tied. All exposed cut surfaces are sealed.

Side Graft.

An alternative method to Side Tongue Graft.

Two slanting cuts, one (A) slightly longer than the other (B), are made at the basal end of the scion at opposite sides to form a gradually tapering wedge. An incision (D) is made in the side of the stock at an angle of approximately 20 degrees and of sufficient depth to allow for the insertion of the above-mentioned wedge. The longer side of the wedge is placed against the stock stem in such a position that the cambial regions of stock and scion are in contact. By bending the stock, so that the incision (D) is

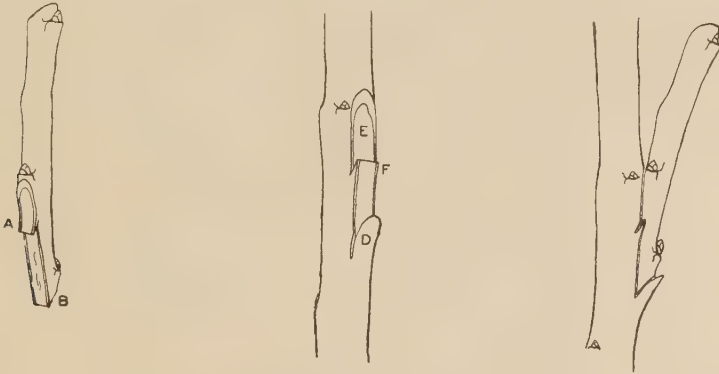


SIDE GRAFT

opened, the scion may be pushed home more readily. All exposed cut surfaces are sealed. Provided the incision (D) is made sufficiently deep into the wood of the stock, the scion is firmly held and tying (but not sealing) is unnecessary, otherwise the graft should be tied firmly.

Side Tongue Graft.

This is employed when it is required to place the scion on the stock without heading the stock back to the position of the graft union. This graft is likely to be very successful when the diameter of the scion is slightly less than that of the stock, and it can be used also when the scion is very considerably smaller than the stock. A long, flat, slanting cut is made at the basal end of the scion. A downward pointing tongue (A) is made in the slanting surface. A short cut (B) is made on the opposite side to form

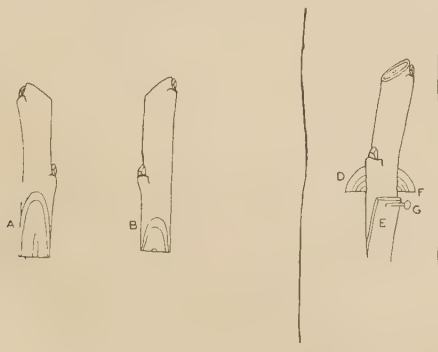


SIDE TONGUE GRAFT

a chisel-shaped base to the scion. An upward pointing tongue (D) is cut in the stock to hold the base of the scion. A downward cut (E) is made as far as the tongue (D) to expose the cambial regions in such a position that they correspond to those of the prepared scion. A tongue (F) is made to interlock with that of the scion. The tongue (D) covers the chisel-shaped base of the scion (B). Stock and scion are bound together and the exposed cut surfaces are sealed.

Slotted Side Graft.

Used when the stock is considerably thicker than the scion. The scion is prepared with its basal end in the form of an unequally-sided wedge (A and B). The stem or

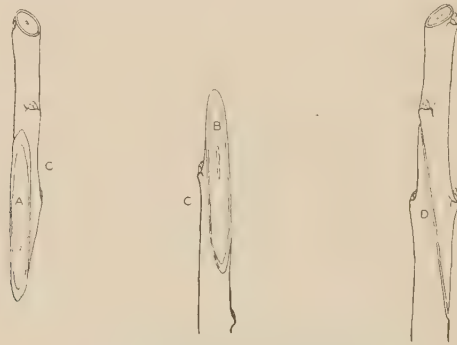


SLOTTED SIDE GRAFT

branch to be grafted receives a downward cut penetrating to the wood. A transverse cut at the base of the downward cut produces a step (D) in the side of the stock branch. Two parallel cuts, very slightly closer together than the width of the scion, are made downwards from the transverse cut. These two cuts should equal the length of the longest slanting cut of the scion. The rind (E) between the parallel cuts is raised slightly and the scion, with its longer cut surface towards the branch, is pushed down under the raised rind until the whole of the tapered base of the scion is below the level of the transverse cut (F) on the stock branch. A gimp-pin or brad (G) is driven through the upper part of the raised rind, through the scion and into the wood of the stock. All exposed cut surfaces are sealed with wax or similar material.

Splice Graft.

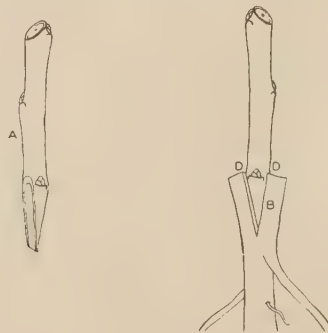
This is one of the simplest methods of grafting stocks and scions of the same diameter. (See also Whip-and-Tongue Graft.) A long slanting cut (A) is made at the basal end of the scion. A corresponding cut (B) is made at the apical end of the stock. The cut surfaces are placed together (D) so that the cambial regions (C) are in contact. When the rind of the scion is considerably thicker or thinner than that of the stock, the matching of the cambial regions brings the surfaces of the rind out of alignment, but this is of little consequence. Stock and scion are bound together and the exposed cut surfaces are sealed.



SPLICE GRAFT OR WHIP GRAFT

Wedge Graft. (Cleft Graft.)

This is often used when scions are grafted directly on to portions of roots. The scion may be of the same or less diameter than the stock. The rind of the root is usually



WEDGE GRAFT

considerably thicker than that of the scion, and in cases where stock and scion appear to be of equal diameter it will often be found that the two cambia are not really coinciding, a condition which may result in failure of the graft.

The scion (A) is prepared with its basal end in the form of a wedge.

The stock is split at its apical end (B) and the scion should be inserted so that the apical portions (D) of the cut surfaces of the scion are just visible and so that at least one side of the cambia of stock and scion are in contact.

The graft requires tying and sealing except where it is possible to obtain a union by placing the graft in moist material.

Whip Graft, *see* Splice Graft.

Whip-and-Tongue Graft.

This method is used when the scion and stock are comparatively small, not more than one inch in diameter. It is similar to the splice graft except as regards the tongue which serves to hold stock and scion together so that the operator has both hands free for tying. Whip-and-tongue grafting is employed to best advantage when stock and scion are of equal diameter. If the stock is considerably larger than the scion it is only possible to match one side of the scion with one side of the stock (E) in such a manner that the cambial regions are in contact.



WHIP-AND-TONGUE GRAFT

A flat slanting cut, the length of which is approximately six times the thickness of the scion, is made at the basal end of the scion. A downward pointing tongue (A) is made in the apical half of the slanting surface. A slanting cut, corresponding in length to that of the scion, is made upwards through the stock. An upward pointing tongue (B) is made in the apical half of the slanting surface. The cut surfaces of the scion and stock are placed together so that the tongues interlock (D) and the cambial regions (C) are in contact over as great a length as possible. Tying and the sealing of all exposed cut surfaces completes the operation.

Inarching.*

In this process the scion remains on the tree until union is complete. The stock is grown or transplanted into a pot which is brought near to the scion by some such means as a platform built under the tree at a suitable level on which the pots are stood, or by insertion of the pot in the cleft end of a bamboo pole. To make the graft the bark and part of the wood of both stock and scion are sliced off for two or three inches along the stems of the stock and the scion. The cut surfaces of stock and scion are then brought together so that the cambia of each are in contact and they are bound in that

* Also known as "approach grafting".

position by a wrapping of waxed cloth. It is preferable that stock and scion should be of the same thickness. When union is complete, the scion should be severed from the tree in three or four stages at intervals of a week. At no time should the pots be allowed to become dry.

Layering. (*See also Etiolation.*)

This can be practised with branches sufficiently low on the ground or the layers may be made in pots of earth standing on raised platforms or in earth spread on the platforms. Rooting and after-growth are slow and the method is not to be recommended except in special circumstances. The layers must be kept watered.

Marcotting.

Also known as the Gootee method, or air layering.

The selected branch is first girdled at the point at which roots are required, a strip of bark about an inch wide being removed. The girdled part is then, either immediately or in a day or so after the formation of a callus, packed with a ball of some rooting compost which may, for instance, consist of a mixture of soil, leaf mould, well rotted cow manure and sand with an outer wrapping of sphagnum moss or other moisture-holding material bound over the whole.

In countries where there is a sufficient rainfall the rooting medium will be kept sufficiently moist; failing that, it must be watered at intervals. An ingenious method of securing a continuous supply of moisture without much trouble is that in which a bamboo joint containing water is suspended above the marcot. From a hole in the bottom of the joint issues a string which is attached to the bandage, and thus by a slow but continuous percolation of water along the string the marcot is kept moist.

TOPWORKING.

The practice of grafting established trees which involves the removal of most of the branch system of the trees is termed topworking. The methods commonly employed may be classed under two heads: (*a*) cleft grafting (sometimes known as split or wedge grafting) and (*b*) rind grafting (sometimes termed bark or veneer grafting).

Cleft Graft.

The base of the scion is prepared by two slanting cuts in the form of a long tapering wedge. The presence of a bud between the two cut surfaces and about half-way between the point at which the cuts begin and the base of the scion is an advantage.

The stem or limb to be grafted is cut off at the point at which it is proposed to graft and the surface is pared smooth with a knife. If the limb is to receive two scions it is cleft diametrically. This cleft is opened by the insertion of a wedge or by using the grafting tool as a lever. The scions are inserted so that their cambial areas are in contact with those of the stock. The wedge or tool is removed and the scions are held fast by the pressure of the limb of the stock.

Should only one scion be inserted in the end of each limb it is unnecessary to extend the cleft right across the limb. It should extend only half-way across and should be sufficiently deep to allow for opening and the insertion of the scion.

A modified cleft graft is that known as the oblique cleft. In this method the limbs of the stock are cleft tangentially or rather along chords of the transverse section of the limb. The clefts do not extend more than half the length of the chord. They are opened by means of the grafting tool and the scions are inserted. Removal of the tool causes the scion to be held firmly in position. Numerous scions may thus be inserted in one limb as required.

Rind Graft (Bark Graft).

In rind grafting the scion is inserted between the rind and the wood of the tree. With all types of rind graft it is essential that the rind of the stock should part

readily from the wood. In the most common method the scion is prepared as for splice-grafting.

The limb of the stock is cut transversely at the point at which it is proposed to graft. The rind of the stock receives a cut of one or two inches in length extending downwards from the end of the transverse cut, and the prepared scion is pushed down beneath the rind so that the cut surface of the scion is towards the middle of the limb. Large limbs receive three or more scions. Unlike the cleft graft this rind graft must be tied firmly in order to retain the scions in position.

Veneer Rind Graft.

In the veneer type of rind graft the scion is prepared as for normal rind grafting except that thin shavings are removed from the edges of the cut surfaces in order to expose the cambial areas.

The transversely cut limb receives two parallel cuts sufficiently wide apart to fit the prepared scion. The scion is pushed down beneath the rind lying between the parallel cuts. The surplus rind is pushed outwards during the process and this is cut off close to the grafted limb. The graft requires tying.

In all methods of top grafting the exposed cut surfaces should be sealed after completion of the graft.

POLYEMBRYONY.

Certain plants, e.g. varieties of mango, *Eugenia* and *Citrus*, produce polyembryonic seeds, that is seeds which contain several embryos, only one or possibly none of which is the result of fertilization, the others arising from cells outside the embryo sac and being thus a form of vegetative budding. If, after germination, the generative seedlings can be distinguished from the vegetative seedlings and eliminated, a pure line of vegetatively-produced descendants should result. The modern practical application of this theory to citrus selection is fully discussed in Technical Communication No. 3 of the Imperial Bureau of Fruit Production (48).

FRUIT VARIETIES

ABERIA GARDNERI Clos. (*Bixaceae*.) Ceylon Gooseberry.

- 72 The fruit is pleasantly acid and suitable for dessert or preserves. The skin should first be removed.
- Budding.* 113 Petioled spineless budwood still bearing tomentum.
- Rootstocks.* 113 Age of stock at point of insertion of buds unimportant.

ACHRAS ZAPOTA L. (*Sapotaceae*.) Sapodilla.

- Among seed grown trees there is great variation in yield, quality, size, shape and flavour of fruit. There is also a large number of named horticultural varieties particularly in Java.
- Budding.* 33, 55, 63, 81 Shield and Forkert methods. The bud should be inserted promptly after the incision in the stock in order to avoid the collection of latex round the wound. In Southern Florida, where shield budding is used, the bud wood is chosen from young half ripened wood in process of turning from green to brown and having well developed axillary buds. In Java the Forkert method is used and the bud wood is chosen from ripe non-petioled one-year-old wood. A time when the stock is in active growth is best. Gonzalez in the Philippines reports that he was unable to shield bud it.
- Grafting.* 33, 63 Splice, cleft, side and bark.
- Inarching.* Presents no difficulty.
- Rootstocks.* 43, 55, 63, 72, 81 In Java two forms of *Achras Zapota* are used as seedling rootstocks, and a number of others have been tried experimentally. The two forms commonly used are known as *Sawo maneela* and *Sawo apel*. Ochse describes them as follows:—*Sawo maneela* has a broad crown, oblong, ovoid fruits, leaves shining, oblong, narrow, acute. *Sawo apel* has a broad crown, dwarfish growth, depressed globose fruits, leaves shining, oblong, narrow, acute, with greatest breadth above the middle. Of the two the buds appear to grow better on *Sawo apel*. *Achras Zapota* seedlings grown for rootstocks will take two to three years before they become large enough to work. Seeds will remain viable for several years if kept dry. Germination takes about a month under tropical conditions. Other suggested rootstocks are *Bassia longifolia* L., Mee tree, *Sideroxylon dulcificum*, the "miraculous fruit tree" of West Africa.
- Mimusoops Kauki* L. used as a stock by A. C. Hartless at Sharanpur, India, induced earlier bearing and a dwarfer habit compared with trees on their own roots. This stock is to be tried at the Hmawbi Agricultural Station, Burma. It has failed to root there from cuttings. Seedlings are not large enough to graft until two years old. Three-year-old stocks of this variety in Java gave 60 per cent. success when budded, both in the wet and dry season. Buds on *Mimusoops Elengi* L., *Chrysophyllum Cainito* L. and *Lucuma multiflora* A.DC. failed.
- Cuttings.* Rooting has been obtained in a solar propagator at the Imperial College of Tropical Agriculture but the percentage was very low (E. E. Cheesman, communicated 1936).

- Etiolation Method.* 53, 55 This method in conjunction with wire ringing is under trial by the S.S. and F.M.S. Department of Agriculture. The latest report communicated stated that repeated trials have been made in various parts of the country but with little success. The plants will root, though many fail, but rooted plants are difficult to establish in bamboo pots and make slow growth.
- Layering.* 81 Layers can be made from branches near the ground and, according to V. H. Gokhale, Principal of the Agricultural College at Poona in 1911, are more vigorous than seedling trees.
- Marcotting.* 4, 56, 63 Marcots take from four months to a year to root, according to variety, and fruit in four to five years. In Ceylon they are stated to reach fruiting size in one year from planting.

ANACARDIUM OCCIDENTALE L. (*Anacardiaceae*.) Cashew.

- Budding.* 4, 113 Shield budding. Non-petioled mature bud wood turning greyish.
- Rootstock.* 113 The same variety. The bud should be inserted at a point where the bark of the stock resembles that of the scion.
- Cuttings.* 6 It can be propagated under glass by cuttings of mature wood, with the leaves retained.

18, 51, 103 ANANAS SATIVUS Schult. (*Bromeliaceae*.) Pineapple.

- Suckers.* The following parts of the plant are used in vegetative propagation :—
1. Suckers. These are produced in the axils of the leaves below the fruit. They are at first nourished by the parent plant, and later send down roots of their own, some of which obtain moisture from the axils of the leaves below and others reach the soil. They form a useful medium of propagation but some of the best varieties do not produce them freely. For planting, a few of the lower leaves are removed but not enough to expose the white portion of the stem.
- Ratoons.* 2. Ratoons, or shoots developing on the stem of the plants, just below the soil. These root directly into the soil. About two are usually left on each plant to take the place of the former fruit-bearing stem, or they can be removed and replanted.
- Slips.* 3. Slips. This name is given to growths which arise on the fruit stem just below the fruit. Being smaller they take longer to fruit than suckers.
- Crown.* 4. The crown or tuft of leaves on the apex of the fruit is much used in certain districts, notably with the smooth Cayenne variety at Bathhurst, South Africa. Naturally it is only available where the fruit is grown for canning rather than dessert. When planting, the lower leaves are removed and it is as well to allow the section to dry in the sun for a few hours.
- Crown Slips.* 5. Slips. These are shoots which arise on the summit of the fruit just below the crown of leaves.
- Stumps.* 6. Stumps. A nursery method not often employed but useful with varieties which are shy in giving other kinds of offshoots. The stem is taken after fruiting, the leaves are trimmed off and the base pared. The whole is then buried in a shallow trench and kept well watered until in due course a number of new shoots arise.
The length of time taken by these various parts to come into bearing varies with the country and variety, but between themselves the relative order is always the same, e.g. in the Philippines the order is—ratoons 12-14 months, suckers 14-16 months, crowns 16-18 months and slips in 2 years.

Sections.
104

What is described as a new method of propagating pineapples has been originated in St. Lucia by the Agricultural Superintendent. It is claimed that this method will produce a large number of uniform plants within a short time. A stem which has not yet fruited is stripped of all leaves except the top six, and, after roots and scales have been cleaned off, is cut into thin cross sections not more than one-fifth of an inch thick. The sections, each of which will have several more or less dormant buds, are then soaked for ten minutes in a 2-5 per cent. solution of permanganate of potassium. After draining they are planted flat on a bed of light soil, thinly covered and well watered. If a solar propagator is used, the rooting medium should be a mixture of chopped coconut fibre and granulated charcoal. When rooting has occurred the sections are taken up and cut into three triangular portions each containing a bud and any embryo rootlets that may have formed. These sections are again dipped in permanganate solution, replanted in the bed and watered with a solution of ammonium sulphate (the strength is not stated). When further growth has been made and a good root system formed the plants can be taken up and replanted in an outside bed. Cotton seed meal, chopped coir, or similar dressings should be freely used. The object of using an unfruited stem is to take advantage of the food reserves present. A stem 1 ft. in length should produce 80 to 100 young plants ready for setting out in nursery beds within six months.

ANNONA. (*Annonaceae*.)

86, 106,
107

Wester, who made a special study of the economic potentialities of the *Annonaceae*, considers their possibilities for improvement by breeding or selection to be greater than those of almost any other group of fruits. There are cold-resisting species from high altitudes and hydrophilous varieties from the swamps. Some have acid fruits and some sweet, while even the qualities of the fruits within a species may be highly divergent. He gives a list of forty-nine species which are worth consideration for hybridization, rootstocks, fruit or ornament. A useful rule in budding Annonas is to use non-petioled, well-matured wood and to cut large buds, since small buds callus over too rapidly. The Annonas referred to are proterogynous, and entomophilous. Failure to bear good crops, especially in alien countries, may therefore be due to lack of the pollinating insects. There are, however, undoubtedly marked differences in cropping ability between seedlings under identical environment.

ANNONA CHERIMOLA Mill. Cherimoya.

Budding.

73, 81, 113

Well-matured, non-petioled bud wood, grey not green in colour, the buds should be cut $1\frac{1}{2}$ inches in length. After the bud has taken, it must be uncovered, but the ties should be replaced (leaving the bud exposed), otherwise the flaps may curl back and dry, in which case a number of buds will perish.

Grafting.

116

Cleft and whip grafting are not difficult, but, to avoid removal of the head of the young tree before the graft has taken, side grafting may be performed, preferably at the base of the stock.

Rootstocks.

6, 81, 113

A. reticulata L., *A. glabra* L., *A. squamosa* L. and its own species have all been used with success. *A. squamosa* gives a dwarf tree. *A. glabra* is liable to outgrow the scion. Stocks three-eighths to half an inch in diameter are of a suitable size for budding. Stocks are cut back to five or six inches above the bud three weeks after budding, at which time the ties may also be loosened. The final cutting back is made when the bud has grown several inches. When grafting is employed the size of the stock seems immaterial to success. *A. Cherimola* is a satisfactory rootstock both for itself and for other species.

Topworking.

116

Trees can be topworked by cleft grafting, or the scion may be inserted at ground level.

ANNONA CHERIMOLA Mill × **A. SQUAMOSA** L. Atemoya.

- 6 This hybrid has fruits much resembling *A. Cherimola* in flavour and is more adapted to tropical conditions.
- Budding.* Use well-matured non-petioled bud wood from which the green colour has
113 disappeared.
- Grafting.* In the Philippines recently cleft grafting on *A. reticulata* L. has given strong
33 growing trees.
- Inarching.* This method has received attention in the Philippines during the last few years.
(See *Rootstocks*, below.)
- Rootstocks.* *A. reticulata* L. seems the most congenial stock, resulting in characteristic
33 vigorous upright growth. Some forms of *A. glabra* L. are also suitable. On *A. muricata* L. the buds are never vigorous and die out after a time ; this stock, however, has been used with success for inarching as, in the Philippines, has *A. squamosa* L.

ANNONA DIVERSIFOLIA Safford. Ilama.

- 81 Described by Popenoe as the finest annonaceous fruit that can be grown in the tropical lowlands. It was not botanically described till 1911.
- Budding.* In Ceylon budding on *A. muricata* L. has not been successful. *A. reticulata*
Rootstocks. L. and *A. glabra* L., however, are more promising.
72

ANNONA GLABRA L. Alligator Apple. Pond Apple.

- 86 This species is now held to be synonymous with *A. palustris* L.
- Rootstock.* Though of no value as a fruit, the variety is often used as a stock for the other
72, 81 species, particularly in Florida. It will withstand a few degrees of frost, and prefers a moist soil.

ANNONA MURICATA L. Soursop.

- Budding.* Modified Forkert, shield and patch budding. The buds should be cut from
55, 72 well-ripened, non-petioled, one-year-old wood.
- Rootstocks.* On year-old stocks of the same species Magielse in Java obtained 100 per cent.
55, 113 success both in the wet and dry seasons. The first fruits were borne $3\frac{1}{2}$ years after budding and averaged 18 per tree. In their fourth year the trees averaged 41 fruits. No success was obtained with *A. squamosa* L., *A. glabra* L., and *Stelechocarpus Burahol* (Blume) Hook. f. and Thoms. On *A. reticulata* L. growth was not very strong and crops were very small, averaging 4 fruits per tree in the fourth year. Wester in the Philippines recommends *A. glabra* and *A. reticulata* as suitable stocks.
- Cuttings.* This variety may be raised from hardwood cuttings.
4

ANNONA RETICULATA L. Bullock's Heart.

- Budding.* The Forkert, patch, and shield bud may be used. The buds should be of non-
55, 113 petioled one-year-old ripe wood.
- Rootstocks.* Ochse states that on stocks of its own species it does badly and recommends
55, 63, 113 *A. muricata* L. Wester in the Philippines has budded it successfully on *A. muricata* L., *A. glabra* L. and *A. squamosa* L. Magielse in Java used ten to

twelve-month-old stocks and obtained 95-100 per cent. success budding on *A. muricata* L. On its own species the buds survived but 5½ years before dying out, while on *A. squamosa* L. they only lasted 2 years. On *A. glabra* L. and *Stelechocarpus Burahol* (Blume) Hook. f. and Thoms, buds failed to take.

ANNONA SQUAMOSA L. Custard Apple. Sugar Apple.

- Budding.* Modified Forkert and shield. Buds from ripe, one-year-old, non-petioled bud wood.
55, 63, 113
- Rootstocks.* Good results are had with stocks of the same species, Magielse obtaining 95 per cent. success in Java in both wet and dry seasons on year-old stocks. The trees flowered in fifteen months after budding and thereafter three or four times yearly. Buds on *A. reticulata* L. died off after three or four days. On *A. glabra* L. and *Stelechocarpus Burahol* (Blume) Hook. f. and Thoms they failed to take. On *A. muricata* results were not good in Java, but Parsons says this stock is used in Ceylon with success. He mentions, incidentally, that the usual cause of ill-health in custard apples can be traced to lack of drainage.

ANTIDESMA BUNIUS (L.) Spreng. (*Euphorbiaceae*.) Salamander Tree.

- Budding.* Employing the Forkert system, non-petioled, ripe, one-year-old bud wood was used in the rainy season in Java with 100 per cent. success. In the dry season the buds take too long before starting growth. In the Philippines Wester shield budded successfully, using petioled, green, smooth, fairly well matured bud wood with brown-coloured lenticels. The buds were cut about an inch long.
55, 63, 113
- Rootstocks.* The stock in Java was the same species raised from seed and budded at six months.
55
- Cuttings.* *Baccaurea racemosa* (Blume) Muel. Arg. was tried as a stock without success. Propagation by this means is not difficult.
63

ARTOCARPUS CHAMPEDEN (Lour) Spreng. (*Urticaceae*. (*Moraceae*)) Champedak (Malaya).

- Budding.* Modified Forkert, using eyes of non-petioled bud wood. Wet or dry season.
55, 63
- Rootstocks.* *Artocarpus integrifolius* L. f. budded at ten to twelve months gave 50 per cent. success in Java. (For certain peculiarities of *A. integrifolius* as a stock see under that name.)
55
- Its own species and *A. rigidus* Blume scarcely gave 20 per cent. success. The former is deep rooting and difficult to lift.

ARTOCARPUS INCISUS L. f. Breadfruit.

- Budding.* Forkert method. Wet or dry season.
55
- Rootstocks.* *A. rigidus* Blume, budded at twelve months old, gave about 50 per cent. success.
53
- Failure resulted with *A. integrifolius* L. f. and *A. Champeden* (Lour) Spreng.
- Marcots.* In experiments in the Philippines *A. incisus* formed roots in about three months.
28
- Root* Cuttings taken from the roots, which may be uncovered for the purpose, root readily in beds of clean river or well-washed sea sand, or, failing that, in sandy loam. The bed should be at least 8 inches deep. A convenient size for the cutting is a length of 8 to 10 inches and a diameter of ⅓-1½ inches. Thicker cuttings will root but are less easy to handle, and their removal is more likely to damage the tree. The cutting is planted firmly in the bed in a slanting position with about an inch of its thickest end above the surface. This exposed end
- Cuttings.*
73, 113

should be treated with some antiseptic sealing preparation. The cuttings require watering and shading and must not be bruised or allowed to dry during the process of planting. This work is best done in the rainy season. In five to six months under favourable conditions the plants should have rooted and grown sufficiently to transplant.

- Stem* Cuttings of lateral shoots will root in a warm, moist, shaded environment but the root cutting method, where practicable, is more satisfactory.
Root The roots which lie quite near and sometimes above the surface will, if wounded at any point, give rise to an offshoot, which can eventually be detached and transplanted. The method is slow, and the young plants are easily injured.
Sprouts. 81

ARTOCARPUS INTEGRIFOLIUS L. f. Jack Fruit.

- Budding.* Modified Forkert, using eyes of non-petioled ripe one-year bud wood. Wet or 55, 63 dry season.
Rootstocks. In Java *Artocarpus Champeden* (Lour) Spreng. is the rootstock preferred, but 4, 55 *A. integrifolius* and *A. rigidus* Blume are also used. *A. Champeden* should be budded at twelve months old and *A. rigidus* at ten to twelve months. In each case about 50 per cent. success can be expected. *A. integrifolius* can be budded when six months old, if necessary. This is not advised owing to the complications caused by the still rapid swelling of the stock against the tie holding the bud in place. The tie has to remain on three weeks. At ten to twelve months, growth has slowed down and this danger does not arise. The percentage of success with *A. integrifolius* as a stock is very variable, ranging from 50-95 per cent. The reason for this uncertainty is unknown, but the abundant flow of milky sap is held to be partly to blame.
Etiolation. Shoots from layered branches root easily in Malaya both with and without ring 53 wiring. A continuous supply of young rooted plants can be thus obtained. When planted out they make rapid growth.
Marcots. In experiments in the Philippines *A. integrifolius* formed roots in about three 28 months.
Root The method of root cuttings used with *A. incisus* L. f. cannot be used successfully
Cuttings. with *A. integrifolius*.
 81
Stem Lateral shoots under warm moist shaded conditions may root.
Cuttings.

54 AVERRHOA BILIMBI L. (*Oxalidaceae*.) Blimbing. Cucumber Tree.

- Budding.* Non-petioled, matured brownish or greyish, still downy bud wood. The bud 55, 113 should be cut about an inch long. In Java 100 per cent. success was obtained when using non-petioled, ripe, year-old wood in either the wet or the dry season.
Rootstocks. Seedling stocks of the same species, raised in seed beds, are ready for transference 55, 113 to nursery beds four weeks later. In Java they were ready for budding in nine months. The bark is very thick but peels easily. Wester says that the age of the stock at point of insertion is immaterial. Buds failed to take with *A. Carambola* L. as the stock.
Layering. This method may be successfully used.

4

AVERRHOA CARAMBOLA L. Carambola.

- 4, 54, 63 There is a great number of seedling forms and the large fruited varieties should be selected.

- Budding.* Both Wester and Gonzalez in the Philippines advise shield budding and the use of petioled, fairly mature, but not old and hard bud wood, of smooth and purplish appearance. The buds should be cut under an inch long. In Ceylon, budding is reported to be very successful.
 4, 33, 55, 113
 Ochse and Magielse in Java both advise budding by the Forkert method, the eyes to be cut from non-petioled, ripe, one-year-old wood. The operation should be carried out in the rainy season.
- Grafting.* Bark grafting has been used with success in the Philippines.
 33
- Inarching.* There is no difficulty.
 33
- Topworking.* The sweet forms have been successfully topworked on the sour by bark grafting.
 33
- Rootstocks.* In Java one-year-old seedlings of the same species are used. Magielse raised the seeds in beds or boxes and put out the resulting plants six weeks later in lightly shaded nursery beds, allowing one foot between the plants. The shade was removed in two to three months, and the plants budded at twelve months with 100 per cent. success. The bark is thin but peels easily. Wester used older stocks and states that the age of the stock at the point of insertion is unimportant. *Averrhoa Bilimbi* L. used as a stock for *A. Carambola* failed to take.
 55, 113
- Etiolation.* Experiments in F.M.S. have achieved some success. As far as these have gone at present wired shoots appear to root less easily than unwired.
 53
- Marcots.* Sometimes used, but rooting is often slow and difficult.
 33, 63

BACCAUREA MOTLEYANA Muell. Arg. (*Euphorbiaceae*.)

- 63 There are forms with sour and with sweet fruits.
- Budding.* Non-petioled, ripe, one-year-old wood. The wood is very brittle and care is needed in cutting the eyes.
 55
- Rootstocks.* Same species. Budded at fourteen months in the rainy season in Java gave 50 per cent. success. The seedling stocks should be kept under heavy shade, being, when young, very sensitive to drought and to strong sunlight. In Java in the dry season it was found necessary to cover the ground with rice straw and water it twice daily. They are ready for transferring to the nursery beds six weeks after sowing.
 55
- Baccaurea racemosa* (Blume) Muell. Arg. as a stock requires the same treatment and gives similar results.
Antidesma Bunius (L.) Spreng. failed as a stock.
Baccaurea dulcis (Jack) Muell. Arg., which has a sweet pulp, would probably respond to the same treatment, but no definite information is available.

BACCAUREA RACEMOSA (Blume) Muell. Arg.

- 63 There is a red and a white fleshed variety and sour and sweet forms of each. They are scarcely to European taste, though popular in the native markets of Java.
- Budding.* Non-petioled, ripe, one-year bud wood. The best time is the rainy season.
 55
- Rootstocks.* On its own species at fourteen months 87 per cent. success was obtained with stocks raised as described under *B. Motleyana* Muell. Arg.
 55 When *B. Motleyana* was the rootstock, similar treatment gave 60 per cent. success.

BIXA ORELLANA L. (*Bixaceae.*) Annatto.

- Budding.* Mature, greenish brown, petioled bud wood ; the bud should be cut about $1\frac{1}{2}$ inches long.
 113
Rootstocks. Same species. The age of the stock at the point of insertion of the bud is immaterial.
 113
Cuttings. The cuttings taken from a flowering plant will produce small trees flowering at an earlier age than seedlings.
 6

BLIGHIA SAPIDA Koen. (*Sapindaceae.*) Akee.

- Budding.* Non-petioled, metallic blue-grey, mature bud wood, cut $1\frac{1}{2}$ -2 inches long.
 113
Rootstocks. Own species. The age of the stock at the point of insertion is unimportant.
 113

CANARIUM OVATUM Engl. (*Burseraceae.*) Pili.

The fruit possesses an edible kernel.

- Budding.* Non-petioled, fairly smooth bud wood, brownish green in colour.
 113
Rootstocks. Insert at point where the wood is approximately of the same appearance as the scion.
 113

CARICA PAPAYA L. (*Caricaceae.*) Papaw. Papaya.

- 78 The papaya can be vegetatively propagated by several methods. Nevertheless, the best results continue to be obtained from seed. In Hawaii, where the vegetative propagation of the papaya has been thoroughly investigated, Pope states that it has been found that neither cuttings nor grafts are possessed of the vigour or fruitfulness of seed-grown plants and further that in failure to reproduce the characters of the parent plants many have proved as variable as seedlings. No method of vegetative propagation so far tried with this plant appears to be of much practical value.

Budding. Ochse says that it can be budded, but does not give further details.
 63

Grafting. Magielse (1930-31) in Java advises side grafting with a single bud as being preferable to splice or cleft grafting. Using this method a 90 per cent. success was obtained. The work must be done in the dry season, the buds rotting easily in damp weather. Suitable grafting material may be obtained by stumping back the trunk of a desirable variety and using the resulting shoots as grafts when sufficiently mature.
 55

29 Fairchild and Simmonds (1913) employed a somewhat different method in Florida. Seed sown under glass in February formed graftable stocks 8-10 inches high in March. They were cleft grafted with scions 3-4 inches long of pencil thickness, obtained chiefly by the heading-back method already mentioned. At the early age at which stock and scion were used there was no central hollow. The grafted plants were shaded and the tie was removed on the seventh day. The scion must not be larger than the stock, but the reverse is unimportant. The grafts so made were planted out in May and fruited by November.

113 Wester in the Philippines (1920) advises cleft grafting or side grafting, but did not in the latter case, as his illustration shows, use the single bud method preferred by Magielse (see above). The grafts should be made about 4 inches above ground on stocks about 1 foot high and not more than $\frac{3}{4}$ inch in diameter. In the cleft graft the cleft should be made to one side of the hollow centre of the stock. In the side graft the incision should not reach the hollow. The scions should be $2\frac{1}{2}$ inches long ; most of their leaves should be removed, but short lengths of the petioles left.

78

Pope, W. T. (1930) at the Hawaii Experiment Station used cleft or whip grafting with seedling stocks 40 days old. The grafts were shaded for two or three days and then exposed to full sun. An interesting attempt was made to transform staminate, non-bearing plants into fruitful ones in a plantation grown from selected seed in which 36 per cent. were males. The male plants were 6 months old and 4 feet high with a trunk diameter of from $2\frac{1}{2}$ to 4 inches, 1 foot from the ground. The scions, a foot long, were chiefly obtained, as previously described, from the forced growth occasioned by topping back the parent tree. Saddle and whip grafts were used, at heights varying from 2 to 3 feet above ground according to the circumference of the scion. Of the two, saddle grafting came to be preferred as stock and scion then make uniform growth all round the stem. As the graft union heals, openings from without into the central cavity are sometimes formed, with the consequent risk of fungal infection. Although the unions were made without difficulty, the plants had periods of slow growth, lacked vigour, failed to fruit properly and in three years were all dead.

Rootstocks.

The stocks are seedling plants of the same variety. Other details on stocks will be found under grafting.

Cuttings.

78

Cuttings can be made to root under certain conditions. In a series of experiments at the Hawaii Experiment Station the following method was successful. The cuttings used were from $\frac{1}{2}$ to 3 inches in diameter and from 6 to 24 inches in length, obtained from lateral branches produced either naturally or through topping. The cut was made at a node. It was found better to use the entire branch which then included the natural swelling at the basal end where the tissue is hard and less liable to decay. Sections of branches were more difficult to root and the resulting plant had a non-typical form. If sections have to be used, the cut ends should be left to dry for a day or two and the end left above ground should be sealed with grafting wax. Large leaves should be removed, leaving a few inches of petiole, which will eventually drop without leaving a wound through which fungi can enter. Various rooting media were used, the highest percentage of success being obtained with cuttings 2 inches in diameter and 24 inches in length set to a depth of 10 to 12 inches in coarse basaltic sand. Trials were made in a propagating house without bottom heat and in the open field. Rooting took place in from 2 to 5 months. The use of bottom heat would probably have accelerated it. Quick rooting is important, because, when whole branches are used, leaves develop in a few days from the terminal buds and are supported by the reserve nutriment in the tissues of the cutting, resulting in a stunting of the trunk supporting them, from which the plant never properly recovers. The roots of the cuttings are sensitive to disturbance and transplanting should be done with a ball of soil attached.

17

In India, Cheema and Dani recommend taking the cuttings with a heel to avoid the stem hollow. They consider the method laborious and uneconomic.

CARISSA CARANDAS L. (*Apocynaceae*.)

Cuttings.

6

Ripe wood in sandy soil.

Etiolation.

53

In Malaya rooted shoots were obtained by ring wiring and successfully established in bamboo pots.

CARISSA GRANDIFLORA A.DC. Natal Plum.

6

Cropping is irregular though continuous.

Layering.

III

Easily layered, it being merely necessary to cover the branches with soil which is kept fairly moist.

Cuttings.

6

Cuttings of ripe wood in sandy soil.

CASIMIROA EDULIS La Llave. (*Rutaceae*.) White Sapote.

- 81, 92 The fruit has a yellowish, soft flesh with a sweet or sub-acid flavour. It is usually eaten fresh. Attempts have been made to preserve it on a commercial scale. At least three named varieties have been established.
- Budding.* Petioled, fairly well matured bud wood of ashen grey colour, best taken from the ends of branches. For shield budding the buds should be cut $1\frac{1}{2}$ inches long, leaving in place any wood which may be behind the bud. The ties can be loosened and rewrapped, leaving the bud exposed, in from two to four weeks.
- Rootstocks.* The stock plants used are young vigorous seedlings and should be budded when in active growth.
- 81

CHRYSOBALANUS ICACO Linn. (*Rosaceae*.) Coco Plum.

- Budding.* Shield budding. Petioled, fairly mature, greenish-brown bud wood with well-developed lenticels.
- 113
- Rootstocks.* Own species. Age of stock at point of insertion of bud unimportant.
- 113
- Cuttings.* Cuttings of half-ripened wood will often grow.
- 6
- Etiolation.* Rooted shoots were obtained in Malaya from seedlings after ring wiring. They proved rather difficult to establish subsequently in bamboo pots. Earthenware pots were better for the purpose.
- 53

CHRYSOPHYLLUM CAINITO L. (*Sapotaceae*.) Star Apple.

- 54, 81 The fruit has a sweet sapotaceous flavour devoid of acidity. There are now several horticultural varieties.
- Budding.* Wester budded this successfully in the Philippines using fairly mature, brownish-grey, non-petioled bud wood, the buds being cut an inch long and being inserted at a point on the stock where it is approximately of the same appearance as the scion. In 1931 Gonzalez in the Philippines reports that he was unable to shield bud this species.
- 33, 113
- Grafting.* Gonzalez reports that the variety was successfully bark grafted but that cleft grafting failed.
- 33
- Inarching.* This has not proved difficult.
- 33
- Rootstocks.* The same species is used. *Chrysophyllum oliviforme* Lam. proved unsatisfactory as a stock.
- 33
- Cuttings.* Well-ripened shoots will often root if placed in strong moist heat.
- 81

COCOLOBA UVIFERA L. (*Polygonaceae*.) Sea Grape.

- The fruit consists of a fleshy perianth enclosing a single seed. It is sweetish acid.
- Budding.* Non-petioled, mature wood, green to greyish.
- 113
- Rootstocks.* Age of stock at point of union is unimportant.
- 113
- Cuttings.* These should be made of mature wood. They root easily in sand, preferably under glass.
- 6
- Layers.* Easily obtained.
- 6

CUBILIA BLANCOI Blume. (*Sapindaceae*.)

- 12, 109 A medium-sized tree bearing a bright green, spiny fruit which contains a single roundish nut of excellent quality.
- Budding.* 113 Non-petioled, half-ripened bud wood, where the smooth green wood is turning brown and roughish.
- Rootstocks.* 113 The age of the stock at the point of insertion of the bud is not important.

DILLENIA INDICA L. (*Dilleniaceae*.)

- Budding.* 113 The wood should be non-petioled, fairly mature, green to brown, pubescent.
- Rootstock.* 113 The age of the stock at point of insertion of the bud is unimportant.
- Cuttings.* 6 These are not easy to root.

DILLENIA PHILIPPENSIS Rolfe.

- Budding.* 113 Fairly mature dark green or purplish, smooth, petioled bud wood.
- Rootstocks.* 113 The age of stock at point of insertion of bud is unimportant.

DIOSPYROS. (*Ebenaceae*.)

- 6 *Diospyros* spp. in general. The sub-tropical varieties can usually be propagated by cuttings of half-ripened wood or by layers, the tropical species by cuttings of mature wood. Bottom heat if available will be of assistance.

DIOSPYROS DISCOLOR Willd. Mabolo.

- 81 There are seedless varieties, and a yellowish-brown fruited sort which is sweeter than the common red variety.
- Budding.* 113 Petioled, fairly mature wood still pubescent. Shield budding is successful.
- Rootstock.* 113 The buds should be inserted at a point where the stock is becoming green or grey.

DIOSPYROS EBENASTER Retz. Black Sapote.

- 81 A popular fruit in Mexico, cultivated in the West Indies and Hawaii.
- Budding.* 113 Mature but green and petioled bud wood is best. The shield buds should be cut $1\frac{1}{2}$ inches long and inserted at a point where the stock is green or brown, before it becomes rough.

DIOSPYROS KAKI L. f. Kaki. Japanese Persimmon.

- 81 The Japanese cultivate more than 800 varieties, but it is doubtful whether more than 90 are of much value.
- Pollination.* 46, 81 In U.S.A. many trees produce pistillate flowers only, though at long intervals the same trees may also produce staminate flowers. To ensure the setting of a crop it is advisable to plant a variety as a pollinator that can be depended on to produce staminate flowers. The variety Gayley is suitable if planted in the proportion of one to eight.
- Budding.* 6, 46, 81, 113 Ring budding is practised by the Chinese. Shield budding gives fair results, though Wester reports unfavourably on it. Hume, however, describes how it can be successfully used in U.S.A. when it is desired to convert a pistillate tree

into a pollen-bearing variety. (See *Pollination*, above.) Shield buds are placed on selected branches where the bark is one to three years old. Preliminary cutting back is not necessary. Tying is done with waxed cloth. As the buds grow the side branches may be cut back, leaving stubs a few inches long to which the growing shoots may be tied. The stubs may be removed the following year. The most suitable time is when the leaves are beginning to open in spring.

Grafting. Cleft grafting usual method. The scions should be stored for some days before use. In France grafting is done in autumn or early spring; in Japan in early spring.

Rootstocks. *D. Lotus* L. is the stock commonly used in the South of France, China and Japan and occasionally in California. Recent rootstock trials in Japan in which *D. Lotus* and *D. Kaki* were compared as stocks for *D. Kaki* gave the following results. *D. Lotus* seedlings had a more vigorous top growth but a thinner root growth and were less resistant to soil moisture extremes and more susceptible to crown gall. All varieties of kaki tested were not compatible with *D. Lotus* but invariably congenial to *D. Kaki* seedlings. Kaki varieties from cold districts were usually compatible with *D. Lotus* but those from warmer districts often were not. Kaki scions on *D. Lotus* show greater winter hardiness than those on *D. Kaki*. Kaki on *D. Lotus* shows earlier foliation and defoliation and has a denser habit than on *D. Kaki*. It is considered that the only advantage *D. Lotus* has over *D. Kaki* as a stock is its superior winter hardiness, and in districts where the possession of this quality is immaterial *D. Kaki* should be preferred. In U.S.A. *D. virginianum*, the common persimmon, is regarded as the best stock plant, though possibly scions on it are shorter lived than on *D. Lotus* which is known to last for centuries in China. However, plants imported into U.S.A. succumb more easily than stocks raised under local conditions. The stocks are usually worked when two to three years old. In the Philippines Gonzalez has grafted with success on *D. Ebenaster* Retz., but the plants are still too young for more to be said than that they are promising.

Root Suckers. This method is used in Java and in the Philippines. Roots are severed but left in the ground. Ultimately the severed ends will sprout.

DIPLODISCUS PANICULATUS Turcz. (*Tiliaceae*.)

12 The starchy seeds when boiled have a good flavour. The mature fruits can be gathered in large quantities with very little labour.

Budding. Petioled, mature, brown to grey bud wood is the most suitable.

113
Rootstock. Own species. Age of bud at point of insertion of stock unimportant.

63

DURIO ZIBETHINUS Murr. (*Malvaceae*.) Durian.

There is a great number of varieties. Desirable qualities are a thick, light-dark yellow, sweet aril without a bitter tang and not too juicy.

Budding. In Java the modified Forkert method is employed with one-year-old non-petioled bud wood. The bark is thick and slips easily. The bud wood must not be stood in water before using or it becomes unworkable. For this reason it is inadvisable to cut the wood earlier than twenty-four hours before use. The buddings are very susceptible to drought and require individual shading for some time after insertion. In the wet season a 90 per cent. success can be expected, in the dry season about 40 per cent. In the Philippines the shield bud has been used with success. In this case the bud should be cut about one inch long. The bud wood should be mature but not so old that it is brittle. The petioles should be removed

55, 63, 81,
108, 113

some time before the bud wood is required so that the scars may have time to heal over and so prevent decay.

Rootstocks. 55 Seedlings of the same species are used when about nine months old. The seed quickly loses its viability, and is very sensitive to drought. The seed beds should, therefore, be covered with straw during the dry season. Germination takes thirteen days. The young budded plants usually suffer severe casualties when transplanted, a 50 per cent. loss being not uncommon. This can be reduced by the promotion of fibrous root growth by cutting round the roots with a sharp spade two months before transplanting.

Etiolation. 53 In Malaya at the Serdang Experiment Station rooted shoots were obtained, after wiring, from pegged-down seedlings. The tendency to produce shoots varied in degree with the individual. The shoots grew to some size before roots appeared. In Wellesley Province rooting occurred but was accompanied by large gall-like growths above the wire. At Singapore roots appeared eight to twelve weeks after shoot growth had begun. The removal of a portion of bark from the shoot seemed to induce quicker root formation.

47 **ERIOBOTRYA JAPONICA** Lindl. (*Rosaceae.*) Loquat. Japanese Medlar.

Budding. 20, 81 Buds should be taken from well-matured wood of previous season's growth. The wood from the bud may be removed, if it slips out easily, but this is not essential. Unpetioled bud wood is best, petioled buds being small and difficult to use successfully.

Grafting. 20, 81 The loquat can be cleft, root, side or whip grafted, either on to stocks in pots or in the nursery row. Shade from hot sunlight will be necessary.

Rootstocks. 49 The following stocks have been used: hawthorn, apple, pear, *Mespilus vulgaris* Reichs., *M. germanica* L., *Pyrus Sorbus* Gaertn. (service tree), quince and loquat. The two last are the most satisfactory. In some countries, i.e. Australia, quince stock is reported to induce early bearing but in California trees on loquat bear the second year after budding. Quince stock is raised vegetatively and thus clonal stocks are easily obtained, whereas loquat stocks have to be raised from seed. Quince is reputed to have a dwarfing effect, but this is not so apparent with the loquat as with the pear, in fact recent comparisons made in Japan between quince and loquat stock showed better growth on quince as well as better crops and a stronger root system. It was found, however, that the buds on loquat gave a higher percentage of takes, 62 per cent. against 40 per cent. In California it is considered that the quince is more easily budded, though its liability to sucker makes it unpopular. It is not always easy to get buds on loquat stock to start and, in order to force them into growth, the tops of the stocks should be cut off to an inch or two above the bud as early as possible (January, in California).

Cuttings. 20 These are best made in autumn, of current season's growth which has hardened and is fairly dormant. They should be cut five or six inches long and be set in sand under glass. Bottom heat will accelerate rooting but is not necessary.

EUGENIA. (*Myrtaceae.*)

The number of *Eugenia* spp. is very large. They are usually raised from seed. Only those recorded to have responded to vegetative propagation are mentioned here.

EUGENIA AQUEA Burm. f. Watery Rose Apple.

There is a red and a white fruited form.

Budding. Modified Forkert method, using non-petioled, one-year, ripe wood.
55, 63

Rootstocks. *Eugenia javanica* Lam.; *Eugenia densiflora* (Blume) A.DC. In Java, year-old stocks of these two species gave 85 per cent. and 70 per cent. success respectively in the rainy season. Buds on *Eugenia Cumini* (L.) Merr. (= *E. Jambolana* Lam.) united well but died a month after the ties were taken off.
55

Etiolation. Roots are produced quickly and easily with ring wiring and possibly without. The rooted plants, however, are sometimes difficult to establish in bamboo pots when taken from the bed.
53

EUGENIA CURRANII. C. B. Robinson.

Budding. Non-petioled bud wood, turning brown and roughish. The bud should be cut 1½ inches long.
113

Rootstocks. The age of the stock at the point of insertion is unimportant. No particular variety of stock is suggested.
113

EUGENIA DENSIFLORA (Blume) A.DC.

55 Used in Java as a rootstock for several species of *Eugenia*. A useful character is its resistance to termite attack. It is easily raised from seed.

EUGENIA JAMBOLANA Lam. (Syn. *E. Cumini* (L.) Merr.). Jambolan, Java Plum.

39, 92 Usually the fruits are too astringent to be eaten raw, but there are certain forms whose fruit is large and palatable. There is a scarce, seedless variety.

Budding. Non-petioled, ripe bud wood. The best time is during the rains. The modified Forkert system is successful.
55

Rootstocks. Own species. About 70 per cent. of takes may be expected. Buds on *Eugenia densiflora* (Blume) A.DC. and *Eugenia javanica* Lam. failed.
55

81, 92 **EUGENIA JAMBOS** L. Rose Apple.

Budding. Greenish to brownish, rather rough, well-matured bud wood. The buds should be cut 1¼ inches long, if shield budded.
113

Rootstocks. The same species could be used, and in this connexion it should be noted that the seeds are polyembryonic, producing four to five plants from a single seed. As with some kinds of citrus this fact might be turned to account in obtaining clonal plants. In Java *E. densiflora* (Blume) A.DC. is considered the best stock. In recent trials 90 per cent. success was obtained in the rainy season with stocks eleven months old.
48, 55

Etiolation. Roots fairly well when ring-wired, but less freely than *E. javanica*. Plants have been established in bamboo pots.
53

EUGENIA JAVANICA Lam. Samarang Rose Apple.

63 There is a red and a white form. The fruits are of better flavour than those of *E. aquea* Burm. f. It is poorly productive on unfertile soil, but bears heavily under favourable conditions.

Budding. Non-petioled, ripe, year-old bud wood. The best time is during the rains. Modified Forkert method.
55

- Rootstocks.* Own species, and *Eugenia densiflora* (Blume) A.DC. The former provides very few seeds so that *E. densiflora* (q.v.), which seeds freely, is the more often available and has the further advantage of being avoided by termites, which is not the case with *E. javanica*. The bark of *E. javanica* strips easily. About 90 per cent. success was obtained in recent experiments in Java with both stocks. In the same experiments no success was obtained with stocks of *E. Cumini* (L.) Merr. (= *E. Jambolana* Lam.) or with the guava, *Psidium Guajava* L.
- Etiolation.* Roots with and without ring-wiring but rooting is freer when wire is used. Owing to the ease with which the plant can be reproduced from marcots, which can be successfully planted direct from the mother tree, plants for layering are easily obtained. Shoots rooted by the etiolation method can be established in bamboo pots, though losses must be expected.

EUGENIA MALACCENSIS L. Malay Rose Apple.

- 63 One of the best of the *Eugenias* both for its fruit and for its ornamental appearance. There is a great number of forms, many inferior.
- Budding.* Non-petioled bud wood. The eyes should not be too old. It has been shield budded in the Philippines and by the Forkert method in Java. The best time for budding is during the rains.
- Rootstocks.* Own species. It is, however, subject to termite attack, and for this reason seedling stocks are difficult to raise. The bark is thick and brittle and is easily damaged if the stock is not in good condition. In Java repeated but unsuccessful attempts have been made to bud this on *E. densiflora* (Blume) A.DC., *E. polycephala* Miq. and *E. Jambolana* Lam.
- Layers.* Thos. Firminger writing in 1869 says that layers have been made.

EUGENIA POLYCEPHALA.

- Budding.* Unpetioled, mature, year-old bud wood. In Java 50 per cent. success was obtained using the Forkert method, the best time being the rainy season.
- Rootstocks.* In stock trials two-year-old stocks of the same variety are the only ones which have given any results. The seed is raised in baskets; heavy shade is necessary for this and to protect the seedlings subsequently.

EUGENIA UNIFLORA L. (Syn. *E. Michelii* Lam.). Surinam Cherry.

- 72, 81, 112 Popenoe considers this to be the best *Eugenia* as far as fruit is concerned. There are improved horticultural varieties, in particular a large black-fruited kind grown in Florida.
- Grafting.* Various authorities recommend whip, cleft or side grafting. Wester says it is easily cleft grafted during the hot dry season in the Philippines. The scions should be 2½ inches long from mature brownish twigs. The stock should be not larger in diameter than 10 mm. and the insertion should be not more than 3 inches above the ground.
- Rootstocks.* No particular rootstock is suggested by the advocates of grafting. If seedling rootstocks of the same species are to be raised, the seed should be sown while fresh. They take three to five weeks to germinate and subsequent growth is slow.
- Suckers.* Some trees produce root suckers freely and thus provide a means of vegetative reproduction or of procuring clonal rootstocks.

109 **EUPHORIA CINEREA.** (*Sapindaceae*.)

- Budding.* Non-petioled, light brown to greenish, mature bud wood which is becoming rough.

- Rootstock.* Own species. *Nephelium longana* Camb. has been used as a stock, but, although the buds took, growth was poor. The age of the stock at the point of insertion of the bud is immaterial.
113

FEIJOA SELLOWIANA Berg. (*Myrtaceae*.) Feijoa.

- 81 There are several horticultural varieties.
Budding. Has been shield budded in the Philippines.
113
Grafting. Whip and veneer grafting, the scions being of firm young wood about the same diameter as the stock.
6
Rootstock. Seedlings of about lead pencil thickness of the same variety.
6
Cuttings. Young wood about four inches long with terminal plants. They root in a month or two with bottom heat, but slowly without.
6
Layers. These will root in about six months.
6

FICUS CARICA L. (*Moraceae*.) Fig.

- Budding.* Ring budding can be used with small stocks, or patch or shield for larger ones. In the case of spring budding, buds are taken from wood of the previous year. Autumn buds should be from succulent wood of the current season.
6, 21
Grafting. Cleft grafting can be done if care is taken to exclude the air. The best time is in early spring.
6
Topworking. One method is to patch or shield bud the trees on branches one to three years old at any time during the growing season when the bark is slipping easily. The buds should be cut large for the older branches. The buds placed early in the season can be forced into growth by cutting back the stock. One or two safety branches are usually left.
21
Cleft and rind grafting are the usual methods of topworking the fig, the former on branches of three or four inches in diameter, the latter on larger limbs. The scions are of two-year-old wood with three or four buds. On large stubs the three or four scions are left for a year, being subsequently thinned to the desired number. The scions and stub are protected by perforated paper collars, and the limbs are whitewashed to prevent sunburn.
Rootstocks. Own species, and usually grown from cuttings. Standardized stocks do not yet seem to be available.
Cuttings. Owing to the ease and rapidity with which it can be accomplished this is really the only commercial method of propagating the fig. The fact that the tree is vigorous and productive on its own roots renders unnecessary the use of a stock, unless one resistant to certain root troubles could be found. The cuttings are taken in winter, of mature, not too succulent wood up to two to three years old. They should be $\frac{1}{2}$ - $\frac{3}{4}$ inch in diameter, be cut just below a node and about 8 inches in length. They are immediately stratified in bundles in somewhat moist sandy soil to prevent drying out. It is important that air pockets should be eliminated by working the soil in between the cuttings. Cuttings taken in spring may be planted at once, but the stratification method is thought to assist callusing. Terminal cuttings are avoided because they are believed to start into growth before the root system is properly formed.
21, 35
Suckers. Suckers which appear at the base of established trees make satisfactory planting material, especially if roots have already developed.
21, 35

72 FLACOURTIA CATAPHRACTA Roxb. (*Flacourtiaceae*.)

Parsons considers this species to be the best of the group. The astringent taste of the fruit disappears entirely if it is rolled in the hand. Seed-grown plants produce a high percentage of males.

- Budding.* Petioled, matured, greenish grey bud wood. Shield buds should be cut about 113 one inch long.
Rootstock. The same species makes the most suitable rootstock. The age of the stock at 72, 113 the point of insertion of the bud is unimportant.

FLACOURTIA INERMIS Roxb. Lovi-Lovi.

- 63, 72, 92 The flavour is sour and astringent, but sweet and large fruited varieties exist.
Budding. Modified Forkert method. Non-petioled, ripe, one-year-old wood. 55
Rootstocks. On seedlings of its own species nine months old, and on *Flacourtia indica* twenty- 55, 63 two months old, Magiels in Java obtained 90 per cent. success in the rainy season. Of the two stocks he prefers *F. inermis*.
Marcots. In the absence of suitable rootstocks the tree can be propagated by marcots. 63 Till recently this was the usual method of procuring clonal varieties.

FLACOURTIA INDICA (Burm. f.) Merr. Rukam.

- The cultivated forms are to some extent worth propagating.
Budding. Modified Forkert method. Non-petioled, ripe one-year wood. 55, 63
Rootstock. On own species twenty-two months old and on *F. inermis* nine months old Magiels obtained 80 per cent. success in the wet season. 55, 63
Suckers. The tree freely sends up root suckers which are largely used for propagation. 63

GARCINIA. (*Guttiferae*.)

- 112 *Garcinias* which fail to grow when budded will often unite rapidly and grow freely when cleft grafted. Well-matured scions should be used.

GARCINIA DULCIS (Roxb.) Kurz.

- 12, 63 An improved form, var. *pyriformis* Boerl, is cultivated in Java below 1,500 feet. Two classes of this variety are recognized, one with small sour fruits of little value, the other with large orange-coloured, pear-shaped fruits with a sub-acid flavour reminiscent of apricot. These are worthy of the horticulturist's attention.
Budding. Forkert or modified Forkert, using ripe, green, smooth, non-petioled bud wood, 55, 112 the bud being cut about 1½ inches long. It has been shield budded in the Philippines, with success when rather large buds were used.
Rootstocks. The same species is used. In the experiments at Ragoenan, Java, Magiels obtained 60 per cent. success with seedling stocks thirty months old budded in both the wet and dry seasons. *G. dulcis* failed to take on *G. Loureiri* Pierre and *Calophyllum Inophyllum* L. Cleft grafted on stocks of *G. Binucao* Choisy it remained alive for six months, but failed to grow. Wester says the bud should be inserted on the stock where the stock has the same appearance as the scion or at most is streaked with grey.
Marcots. Marcotting is possible but difficult. 63

GARCINIA HOMBRONIANA. Wild Mangosteen (Malaya).

- Etiolation.* In Malaya ring-wired seedlings produced a few roots and were subsequently 53 established in pots. Root growth was slow.

GARCINIA MANGOSTANA L. Mangosteen.

Budding. 15, 63, 113 Mature, green, smooth, non-petioled bud wood. The buds are cut one inch long and should be inserted at a point on the stock corresponding in appearance to the scion or at most where it is streaked with grey. Although Wester in thus describing without comment the nature of the bud wood seems to imply that there are no special difficulties, at any rate in the Philippines, workers elsewhere have been less fortunate. Ochse in Java remarks that budding experiments have not given the results desired. At Peradeniya Gardens, Ceylon, no successful results have been obtained.

Grafting. 15, 68 The Acting Curator of the Royal Botanic Gardens at Peradeniya states that on a neighbouring estate the wedge grafting with mangosteen stocks has been fairly successful. The Curator of the Government Botanic Gardens, Ootacamund, Madras, in a communication, states that grafting the mangosteen on the only other available stock, *G. Xanthochymus* Hook f., has proved abortive. He attributes this to the exudation of "gamboge" from the cut surfaces preventing complete union. Here it might be mentioned that the same difficulty of exudation occurs in the vegetative propagation of the walnut. It is successfully overcome by the use of patch budding, the two horizontal cuts being made in the stock six days before budding. With this method there is no fermentation from excess sap and possibly a greater storage of food in the surrounding tissues. Other methods of budding the walnut meet with small success.

Inarching. 15, 67, 93 Oliver in his experiments under glass at Washington was successful in uniting *G. Mangostana* with about twenty different stocks, but considered only a few of them as promising. (See *Rootstocks*.) In the conditions under which Oliver worked it was found convenient to lift the seedling rootstocks with a ball of soil, which was first enveloped in coir and then tied up in cloth and kept moist. The stocks were then inarched on twigs of the scion plant. Any strain due to the weight of the soil was eliminated by tying the ball to the stronger branches of the scion. After union was complete the scion was gradually removed from the parent by a progressive deepening of a cut below the union at intervals of a few days. More recently, in correspondence dated May 17th, 1933, the Acting Curator of the Botanic Gardens, Peradeniya, states that there the inarching of the mangosteen, using *G. cornea* L. as a stock, has been fairly successful, but that the inarched plants have made practically no growth since they were planted. In Java inarching on plants of the same species has not been successful.

Rootstocks
(and
Inarching). 67, 81, 108, 112, 115 The difficulty with the mangosteen is to get it to grow strongly on its own roots, which are small or weak and are very apt to resent drought. Most of the other varieties of this large genus of over 400 species are strong-rooted plants with well-developed root systems even in the seedling stage and among the large number congenial stocks should not be impossible to find. The budding or grafting of guttiferous plants presents no great difficulty. Most of the *Garcinias* are easily raised from fresh seed. Oliver reports as follows on the seedling stocks inarched under glass at Washington. The soil mixture in which he found germination easiest was made up largely of partially decomposed leaves mixed with a little loam and coarse sand. The stock plants should be in active growth when the inarch is made. In the greenhouse this activity was induced by allowing the stocks to become dormant, then repotting them and placing them in a high temperature. The increase of subsequent growth over stocks inarched when dormant is very marked. The mangosteen scions, however, could be apparently dormant without ill effects. Oliver succeeded in getting all the twenty varieties of *Garcinia* that he used as stocks to unite, but, judged in the light of subsequent behaviour, the most promising were *G. tinctoria* (Malaya), *G. Morella* Desr. (Malaya), *G. Livingstonei* T. Anders (Tropical Africa), in the order named.

Mangosteen seedlings seven months old inarched on three-year-old *G. tinctoria* stocks had in six months increased in girth nearly to the size of the stock. Oliver also experimented with other genera of the same family as stocks for the mangosteen. *Calophyllum Calaba* Jacq. (Tropical America) and *C. Inophyllum* L. made unsatisfactory unions owing to their stems being softer and their growth more rapid than the mangosteen. *Platonia insignis* Mart. made good unions. It was found that with *Platonia* as a rootstock scion rooting often occurred. In some cases the stock subsequently rotted, leaving the mangosteen growing strongly on its own roots. In cases where the mangosteen retained both the scion and stock roots it grew with a greatly increased vigour. *G. cornea* L. has been used as a stock in Ceylon (See *Inarching*). *G. Xanthochymus* Hook f. shows promise but union is sometimes hampered by sap flow. *G. Benthami* Perr., a vigorous drought-resisting variety, gave good initial results in the Philippines, the young trees (inarched) attaining the height of about $3\frac{1}{2}$ feet in under two years.

Seed.
68

Although this communication is intended to deal exclusively with the vegetative propagation of such fruit trees as are amenable to it, no successful method of raising so difficult and delicious a fruit as the mangosteen should be omitted. For this reason the following interesting letter from the Curator of the Government Botanic Gardens, Ootacamund, on growing the mangosteen from seed is included here.

"For many years we were also unsuccessful in propagating the mangosteen from seed, but it was eventually discovered that this was due to insufficient depth of soil in the seed bed, the mangosteen seedling producing an abnormally long tap root, which, in the case of two-year-old seedlings, may be as much as two feet in length with practically no lateral roots. It was found that if these extremely fine tap roots encounter a stone or very hard soil the seedlings receive a check which prevents further growth. Hence a depth of no less than three feet of good soil is the first essential for the seed bed.

The method of propagating the mangosteen employed with success at the Burliar and Kallar stations is briefly as follows :—

(1) Select well-developed seeds from large fruits only, and place them in powdered charcoal, leaving the surrounding pulp intact, and sow within a week in deep seed beds prepared as described above.

(2) Keep the soil fairly moist until germination takes place, which will be within a month from sowing, after which more frequent waterings should be given. Keep the seedlings shaded from direct sunlight.

(3) When the seedlings are about six inches high, which will be within a year from sowing, transfer to specially made pots $1\frac{1}{2}$ feet deep by 4 inches in diameter (or if these are not available bamboo joints will do), taking care not to injure the tap roots when potting, otherwise *the plants will receive a check from which they will never recover.*

When the seedlings are about two years old they will be large enough to plant in their permanent quarters, and when doing so, use the same care in preparing the soil as for the seed bed, adding a fair quantity of well-rotted cattle manure and a sprinkling of bone meal. When planting, great care should be taken not to disturb the roots. After-treatment consists in keeping the plants well shaded and the soil constantly irrigated in dry weather.

The growth of the mangosteen at Kallar is extremely slow and varies considerably in individual plants probably according to whether or not the delicate tap root receives a check. Young plants at Kallar planted in 1924, although healthy, are now only about four feet high and have a tap root five feet in length. From observations at Kallar, the seedling mangosteen will commence to bear fruit in about fifteen years from planting."

Given a warm climate the situations in which the mangosteen seems really at home are those where a continual supply of fresh water is always available and, though this may be supplied by irrigation, the ideal position is one in which a water table of fresh, not stagnant, water lies within six feet of the surface.

GARCINIA VENULOSA Choisy.

Budding. Non-petioled, green, smooth bud wood.

113

Rootstock. The bud should be inserted where the stock is green and smooth, or slightly streaked with grey.

113

GENIPA AMERICANA L. (*Rubiaceae*.)

Budding. Mature, smooth, non-petioled wood; bluish green in colour.

113

Rootstock. Own species. Age of stock at point of insertion of the bud is not important.

113

GNETUM GNEMON L. (*Gnetaceae*.)

109, 112 The edible part of the fruit consists of one large seed containing nearly 50 per cent. starch.

Budding. Unpetioled, mature, one-year-old bud wood gave 90 per cent. success in Java in both wet and dry seasons, using the Forkert method. In the Philippines it has been shield budded.

55, 113

Grafting. It is easily cleft grafted, if well-matured scions are used.

112

Rootstocks. The stocks used in Java were fourteen months old and of the same variety. It was necessary to file the hard coated seeds which then germinated in a month, whereas unfiled seeds took six months.

55, 112

Gnetum indicum Merr. could not be grafted on to this variety.

GREWIA ASIATICA. (*Tiliaceae*.)

Budding. The bud wood should be petioled, mature, brownish and still bearing tomentum.

113

Rootstock. The age of the stock at point of insertion of bud is unimportant.

113

HICORIA PECAN Engl. and Graeb. (*Juglandaceae*.) Pecan.

83 The pecan has never been considered an easy subject for vegetative propagation and in the past propagators achieving a 50 per cent. success would consider they had done well. However, considerable attention has recently been given to the subject, principally in America, and as a result of this experimental work the propagation of pecans can now be undertaken by those prepared to follow the rules with the certainty that the percentage of failure will no longer be great.

Budding. In Georgia the usual season for budding is from midsummer onwards. This enables the first formed buds of the current season to be employed while the young plants to be used as rootstocks will have had more time in which to grow to a suitable size. Buds of the previous season can also be used (dormant budding) in spring as soon as the bark begins to slip. There is also a third class of bud known as reserve buds which normally are not used by the tree except to replace some injury. They are usually found at the beginning of a year's growth, those on the one-year-old wood being preferred. They have the advantage that they can be used fresh at any time of the year, but, since cutting the bud wood entails

5, 6, 10,

83, 91, 101

the destruction of all the current season's growth on the branch from which they are taken, it is not advisable to use them except in case of necessity. In the case of dormant budding the previous season's wood can either be cut straight from the tree as required with the attendant risk that an early spring may force it into growth on the tree before it can be used, or it can be cut during the dormant season and stored. Storage wood may be cut from late autumn to early spring, preferably the latter, unless winter injury is to be feared, and stored in a temperature of 32-38° F. Precautions against desiccation consist in dipping the cut ends of the wood in melted paraffin wax, covering it with moist sand, moss, sawdust, etc., and keeping it in a cool cellar. It may also be placed in cold storage, where it will keep almost indefinitely if the temperature does not go much below freezing point. Scions may also be wrapped in paper or burlap and buried. Before storage wood can be used for budding it must be subjected to conditions of warmth and humidity for twenty-four to forty-eight hours, the purpose of this "seasoning" being to cause the bark to slip readily. The buds must be used before they show signs of swelling. Unused seasoned wood can be returned to store for use at a later date. It is not always easy to get the bark to season well. The reasons for this have now been investigated and the results published. In summer budding the leaf petiole is cut off half an inch above the bud. If this is done some days before use, the petiole will drop off, leaving a healed scar. The presence of the petiole stub makes for easier manipulation, but evaporation through the cut end may lead to a serious weakening of the bud. The following methods are used :—

Patch Budding. This is perhaps the most usual method. The height from the ground at which the bud is inserted may be from two to ten inches and according to Stukeley appears to be governed by the diameter of the stock at point of insertion. This should be not over one to two inches with young seedling stock. The method can, however, also be used on mature trees.

Ring Budding. This method is often successful with those pecan varieties which are "difficult". Here the scions used have a diameter of about $\frac{1}{4}$ to $\frac{3}{4}$ inch. The width of the bark removed is about one inch. In both patch and annular budding the most suitable buds to use are those situated in the axils of the leaves at the base of the current season's growth. (Illustrations of special tools for ring budding will be found in U.S. Dep. Agric. Farmers' Bulletin No. 700, 1922, Pecan Culture, by C. A. Reed.)

Flute or Modified Patch. A development of an improvement on ring budding. It allows contact of the cambium of bud and stock along the vertical as well as the horizontal cuts.

Shield Budding is not considered so satisfactory for budding pecans as the foregoing methods, though Tribolet in South Africa has recorded that the modification known as the upright H or side $\boxplus$ gave a fair percentage of takes. In these methods the flaps of bark from the transverse cut are turned upwards and downwards with the upright H, or to right and left with the side $\boxplus$, and the bud inserted. The upper and lower edges of the bark surrounding the bud on the side edges in the case of the side $\boxplus$ are bevelled down with a sharp knife. The method is recorded here as a matter of interest. It is not recommended.

Chip Budding. Stored bud wood (*see Budding*), taken while the tree is thoroughly dormant, should be inserted just before the stock starts into growth, though success to a lesser degree may still be obtained until the stock is in full growth. After insertion the point of union is wrapped in waxed cloth with an opening through which the bud protrudes. Chip buds of pecans require forcing into growth. This is accomplished by removing any buds on the stock which show a tendency to grow. It will have to be done several times. Should the

chip bud fail, the stock can be allowed to grow one or two shoots which will be ready for patch budding by the summer.

Grafting.

5, 6, 83, 91

Nursery Whip Grafting. This operation is performed during the latter part of the dormant season with scions of the previous season's growth taken straight from the tree and containing two to four buds. Complete dormancy is essential. The union is made from just below the soil surface to several inches underground, the soil being removed for the purpose and replaced after the graft has been made, covering the graft except for one inch at the top. String is used for tying material, as this rots before it has time to girdle the tree, and the need for loosening is obviated. There is a tendency for trees with low stock and scion unions to suffer more from winter injury than high-worked trees. The method succeeds best on the moister lands. It is, like all grafting, wasteful of bud wood and takes longer. Patch budding is now almost universally preferred.

Cleft Grafting. This method is mainly used in top or crown grafting and is most usefully performed during late winter or very early in the growing period. Scions should be of wood of the previous season. The use of terminal twigs, once customary, is no longer advised since the terminal bud rarely develops satisfactorily. *Bark Grafting* is used successfully in topworking old trees.

Rootstocks.

5, 6, 83,

101

Rootstocks are raised from seed and are usually budded when two years old. Trials at the Georgia Experiment Station with over forty varieties of pecans and with wild seedlings have failed to detect any superiority for rootstock work either between varieties or between varieties and seedlings. At a certain stage a few weeks before maturity all nuts have practically the same chance of producing vigorous seedlings. How they subsequently develop is dependent on some other factor than variety and in this connexion proper ripening and storing are important. The best germination has been obtained from nuts buried in the soil in a wire basket throughout the winter. Nuts stored at or just above freezing point in high humidity also germinated well. The highest germination in a series of storage experiments was 67 per cent. (underground wire cage treatment). These seedlings had also made the best growth at the end of the season. Pecans germinate and grow best with the soil acidity about neutral but are on the whole more alkaline than acid tolerant. Experiments in aiding germination produced the best results (100 per cent.) when the nuts were treated with a concentrated solution of ammonium hydroxide for two minutes or with ammonia fumes for one, two and three days. Untreated nuts gave 76 per cent. germination. The most suitable planting depth has been found to be four times the depth of the nut, the position of the nut in the soil being immaterial. The seed beds should be shaded or mulched. There is good compatibility between pecans and some hickories.

Topworking.

5, 6, 83, 91

Trees under fifteen years of age are the most successfully topworked. The methods used are (a) cleft grafting; (b) bark (rind) grafting on cut back stumps or branches; (c) budding on shoots produced as a result of heading back the trees; this method is often used on shoots which arise from stumps on which (b) has failed; (d) patch budding direct on to the bark of limbs or trunk. In (a), (b) and (c) sufficient lower branches are left uncut to carry on the vegetative processes of the tree until the new top has formed. In (c) the new sprouts after preliminary thinning are ready for budding by late summer or budding or grafting the following spring. Disadvantages are that the top has to be formed twice, once when the tree is cut over to produce the shoots, and again when the shoots have to be cut back to force the bud. This often results in greatly weakening the tree. In (d) the rough bark on branch or trunk (their diameter should not exceed two or four inches) is pared down and the patch bud inserted on the tender underlying bark. The stock is not cut back at all until it is seen that the

bud is living, and then only sufficient is cut to start the bud into growth. This is often done by only partially cutting through the wood above the bud, the surplus wood of the stock being completely removed when growth starts the following spring. Patch buds on branches should not be placed too far from the main trunk or the tree may become top-heavy.

The pecan may be top grafted on to various hickories but, though the subsequent growth is strong, it is often unfruitful.

There appear to be no records of stem cuttings having rooted.

Stem
Cuttings.

Root
Cuttings.

5

A certain form of so-called root cuttings can be used. A severed tap root will send up many shoots from the ground, or if lifted and laid in cutting beds it will also grow. Piece roots succeed only to the extent of about 20 per cent. In view of this tendency to sprout from severed roots the etiolation method might prove to be a means of inducing the shoots thus produced to throw out roots and so to provide a nucleus of clonal plants.

INOCARPUS EDULIS Forst. (*Leguminosae*.) Otaheite Chestnut.

Budding. This variety has been successfully shield budded in the Philippines.

113

LANSIUM DOMESTICUM Corr. (*Meliaceae*.) Langsat. Duku.

63

The fruit is juicy with a sub-acid aromatic flavour. Popenoe considers it is one of the best fruits of the Malayan region and offering a pleasant contrast to the cloying sweetness of so many tropical fruits. In Java, however, the Dutch taste is for certain very sweet varieties (*L. d.* var. *typica* Backer).

Budding.

33, 55

In Java unpotted, mature, year-old bud wood applied during the rainy season gave 60 per cent. success using the modified Forkert method. The bark is very thin and tears easily and the buds must be inserted immediately they are cut or they will dry out rapidly. In the Philippines shield budding gave poor results.

Grafting.

63, 113

Cleft and side grafting, particularly the former, is a successful method in the Philippines but not in Java. The scions should be of matured but not old wood, 2-2½ inches long and about ½ inch in diameter.

Rootstocks.

55, 63

Seedlings of the same species about four years old for budding and from two to three years old for cleft grafting seem to be the most suitable stocks. Ochse reports that duku when budded with duku gave in its second year a more rapid growth than did seedling plants, though there was a delay in starting the first year. Budding on *L. d.* var. *pubescens* Kds. and Val., the kokosan, gave only 16 per cent. success, while on *Sandoricum koetjape* (Burm. f.) Merr., *Aglaia rufa* Miq. var. *celebica*, *Carapa guianensis* Aubl. and *Dysoxylum macrothyrsum* Miq. all buds failed. Raising stocks from seed requires a certain amount of care. In Java five or six seeds are planted in a basket of richly manured soil and kept under a palm leaf shelter. In a year those which germinate will be one foot high and they are then planted out in heavily shaded nursery beds. The beds are mulched with straw and in the dry season are watered twice daily.

Topworking.

33

Cuttings.

These usually failed to root.

33

Etiolation.

53

Duku is reported from Malaya to root easily without wiring, but subsequent growth is slow.

Marcots.

63

Roots are produced but the plants are difficult to keep alive afterwards.

MACADAMIA TERNIFOLIA F. Muell. (*Proteaceae*) Queensland Nut. Austrian Nut.

- 26, 77 The most extensive experiments in the vegetative propagation of this nut hitherto appear to have been done by the Hawaii Agricultural Experiment Station, but both the Queensland and the New South Wales Departments of Agriculture are now carrying out investigations.
- Budding.* Shield budding was not successful in Hawaii but is said to offer encouraging prospects in New South Wales.
26, 77
- Grafting.* In Hawaii whip grafting and wedge grafting failed. Side tongue grafting succeeded to a certain extent with material five-sixteenths to one-half inch in diameter both in Hawaii and New South Wales.
26, 77
- Inarching.* Root and basal shoots can be inarched on to rootstocks in pots. Inarching higher up the tree is inconvenient, since it entails the use of scaffolding to raise the stock up to the branches of the scion. In making experimental inarches in Hawaii a strip of bark and wood half an inch wide was removed from both stock and scion and the two exposed surfaces were bound lightly together with raffia and sealed with paraffin wax. Union was complete in about a month. On removal from the parent tree the top of the stock was cut off just above the point of union and the scion was cut off just below it and about half of the scion leaves were also removed. Paraffin wax was used to seal the cut stem surfaces. New growth started nineteen days after removal from the tree.
77
- Rootstocks.* These have so far been raised from seed and grafted when from eight to fifteen months old or at any time when their size and the nature of their wood is suitable. Round nuts with solid kernels should be selected and planted immediately they are mature. Hemispherical nuts and those with loose kernels germinate badly or not at all. Seed beds must be kept well watered and the seedlings should then appear in about a month. A rootstock resistant to low soil temperatures will probably be required in some countries and possibly propagation by cuttings (q.v.) may provide the best means of propagating this when found.
26, 77
- Topworking.* Mr. R. Allsopp of the Queensland Acclimatization Society topworks successfully by means of the slotted side graft. He advises placing the grafts at the base of the branches near the trunk and inserting three scions on each selected branch. After growth has started the two weakest scions should be eliminated. The worked branches remain to carry the crop and are then headed back to the new grafts.
2
- Cuttings.* This may prove to be a useful method of propagation on a large scale by which either standardized rootstocks or trees on their own roots might be obtained. The most successful cuttings have been produced from mature branches one to two feet long and half an inch or more in diameter, planted in a deep, well-drained soil composed largely of humus. Other conditions making for success are a temperature of 65-70 degrees F., shade from strong sun, and plenty of moisture. A good root system should have developed in five months at most. Top growth proceeds in a series of flushes, and transplanting should be done during an apparently dormant period.
77
- Marcots.* Branches four feet long and one inch in diameter, with a ring of bark removed and the wound packed with a ball of compost made up of equal parts sphagnum moss and rich potting soil, rooted well within sixty days. The labour-saving method used in Hawaii for the litchi (*Nephelium Litchi*, q.v.), by which several branches are layered in one box might be successfully used also with the *Macadamia*.
77

MALPIGHIA GLABRA L. (Malpighiaceae.) Barbados Cherry.

Budding. Light grey to greenish, mature, petioled bud wood.

Rootstocks. Own species. The age of stock at point of insertion of the bud is immaterial.

Cuttings. Bailey states that the plant can be propagated by cuttings but does not mention their nature.

MANGIFERA INDICA L. (Anacardiaceae.) Mango.

Budding. *Forkert.* In Java 80-90 per cent. success is claimed for the *modified Forkert method* used during the dry season with one-year-old, petioled, ripe bud wood. The bud is cut with a thick wedge of wood behind it, which is removed without damaging the woody core of the bud immediately before insertion. The stock is not cut back until the bud begins to shoot, in from four to six weeks.

Shield Budding is used in many countries. In performing this operation it should be remembered that the peculiarity of the mango bud is that it forms its union with the stock plant under the bark only and not at the sides, so that there is a tendency for the bud to be raised up on a cushion of rapidly dividing cambium cells. To check this activity and to induce the formation of wood, it is usual to prune to some extent the developing branch system of the bud shoot. In budding with the inverted T method (L) the bud should be pushed well up into the vertical portion of the cut, which will hold the bud while the lower edges of the incision are carefully cut away to allow the bud to rest flat in a Δ -shaped opening. If this is not done, wound gum from the upper edges of the cortex may filter into the space at the back of the bud and prevent a union.

Patch Budding may also be used, but it is more troublesome and less successful. The usual height for placing the buds on the stocks is six inches from the ground. Temporary shade until the buds are established should be given to budded plants in all cases.

The *bud wood* selected should be fairly mature, round, straight, smooth, green and as dormant as possible. These qualities will be found in the second and third flushes from the ends of the branches.

In the Java experiments petioled bud wood was used successfully in the dry season, but elsewhere unpetioled wood is preferred. To secure this without cutting off the petioles at the time of budding and thus leaving a wound through which fungi may enter, the leaves should be removed from the selected scions while they are still on the parent tree. In about two weeks the petioles will have dropped off, leaving underneath a healed scar.

Grafting. Generally the scion wood should consist of healthy, firm, terminal shoots about three-eighths to one-half inch in diameter, but in case of shortage a second cut may be taken from the same branch. The usual length of scion is five to six inches. In Hawaii it is the practice to remove the scion wood from the tree a day before grafting and to pack it in damp sphagnum moss enveloped in oiled paper. Thus packed it will keep for a week under cool conditions. The leaves of the scion are removed, leaving only the stumps of the petioles.

Methods of Grafting. The side tongue graft is a successful method used in Hawaii, provided it is carefully done. In order to ensure that the union is closely bound, which is vital to the success of the graft, it is customary to tie with moist raffia which tightens as it dries. The whole union including the tie is painted with a low-melting (120° F.) paraffin wax applied as a lukewarm liquid. This prevents evaporation, while permitting the action of light on the chlorophyll in the green bark to continue, and modifies action of the heat rays. Contrary to what is desirable with other methods of grafting, it is not necessary

Mango budding.

The following method of budding in the nursery, for which much success is claimed, has been devised at the Jaffna Farm School, Ceylon and is fully described and illustrated in Trop. Agriculturist, 1937, 88 : 86-91. Hort. Abstracts, Vol. 7, No. 3, September 1937.

The rootstocks used are seedling mangoes, 6 months to 1 year old, growing in nursery beds. To prepare the stock 2 parallel vertical cuts $1\frac{1}{2}$ -2 inches long are made in the bark and are joined at the top by a horizontal cut. The flap thus prepared is pulled gently down leaving a patch of cambium surface exposed. The bud is taken from the current season's growth showing a pale green colour and a smooth surface. The petiole is removed except for a stub of $1/10$ inch. The bud is then cut so that it forms the centre of a shield about $1-1\frac{1}{2}$ inches in length and of an area slightly less than that of the prepared patch on the stock. The cut is made so that a wedge of wood remains underneath the shield. The shield is then placed in the centre of the stock patch in such a manner that its sides or extremities do not touch the edges of the patch. The flap is now pulled up over the bud, the whole being covered with waxed tape wound round it in puttee fashion. In hot weather the bud is protected by a strip of dry plantain sheath, 3 x 5 inches, tied on the stock above and below. During wet weather the bud is covered with oil paper. The tape is unwound in 2-3 weeks. If the bud is still green it has probably united. The plantain sheath is put back and is removed a week later when the stock is ring-barked $1\frac{1}{2}$ -2 inches above the bud. The final cutting back of the stock takes place when the bud has grown to a length of 3-4 inches.

with the side tongue graft for the terminal buds of scions or stocks to be in a flush condition. Whip grafting, saddle grafting and wedge grafting are used with varying degrees of success in which the skill of the operator plays an important part.

*Embryo
Grafting.*
99

Grafting a sprouting mango embryo has been successful in experiments. The plumule is cut off near the base of the cotyledons, a slit being made between them, and a wedge-shaped scion two to four inches long is inserted, tied with a rubber band, and coated with paraffin. The operation requires care to avoid breaking the brittle embryo.

Inarching.
50

Inarching on pot-grown seedling stocks about a year old having a diameter of about half an inch is still the chief method of propagation in Eastern countries where labour is cheap. The selected scion should be of the same thickness as the stock. Trees propagated by this method are often short-lived or stunted compared to seedlings. This was in India formerly attributed to the cutting off of the tap root before potting up for the operation, but of late a theory that the operation of inarching itself is responsible has obtained considerable support.

Rootstocks.
6, 13, 48,
55, 64, 66,
76

In Java, where research on the subject of mango rootstocks is being actively pursued, it has been found that the degree of compatibility between stock and scion is dependent on the varieties employed. The usual seedling stock is a local variety of *M. indica* known as *mango madoe* which proves successful with all *M. indica* forms.

In Java experiments are at present directed towards the discovery of further stocks which will produce fairly uniform material from seed after selection in the seed bed if necessary, as in the case of citrus, with the object of ascertaining the influence of such stocks on the growth, cropping and periodicity of the scion and of investigating the influence of the various types of soil on the growth of the stocks. The fact that the Java types likely to form useful stocks are polyembryonic should prove advantageous, since their seedlings will thus be mostly of vegetative origin (See *Polyembryony in the Mango*, below).

The age at which the seedling stocks can be grafted is from six months to three years. It must be borne in mind that the older stocks present difficulties in transplanting if grown in the open, and that if kept in pots there is a danger of the roots becoming pot-bound, and imposing a check from which the plants often never recover. On the whole eight- to fifteen-month-old stocks will generally be the most satisfactory and the stock should be in growth, otherwise the bark will not peel.

In Western India the grafting of one huge scion on two small stocks is not unusual. The arguments advanced by the native gardener (there is no experimental evidence) are that these big plants fruit earlier and are stronger and more durable than young scions on single stocks.

Raising Seedling Stocks. In Hawaii the best results are obtained as follows :—Seed selection is made from fruits during the mid-fruiting season, seeds from early ripening fruit often lacking in vigour. The seeds are sown as soon as possible after removal from the fruit and the husk is taken off before planting the kernels, the best method of doing this being to clip the edges with shears. The wet slippery nature of the husk is counteracted by rolling it in sand. The kernels are placed edgewise to a depth of three inches in large propagating benches holding one foot depth of washed coral sand. Their main requirements under Hawaiian conditions are aeration and moisture, but the propagating benches are kept in direct sunlight to ensure stocky growth. Grafting is possible when the plants are six to eight months old. To induce the flush of growth which is usually desirable at grafting time, each plant is given one pint of one ounce to the gallon solution of nitrate of soda about a week before grafting.

- 13, 65, 69, *Stock Varieties*. In Java, in addition to the successful *M. indica* variety *mangga madoe*, the following have been tried :—*Mangifera odorata* Griff. and *M. foetida* Lour. The budded plants grow well for two years but later signs of incompatibility appear. With *M. odorata* many plants die off, while with *M. foetida* thickened ridges appear round the bud union, which is usually poor. Parsons notes that in addition to *M. indica*, *M. zeylandica* is a useful stock in Ceylon. In St. Lucia a variety called Long is recommended.
- Stocks other than Mango*. Unsuccessful experiments have been made in India in grafting mango scions by various methods on the following stocks :—*Semecarpus Anacardium* L. f., *Spondias mangifera* Wild., *Spondias acuminata*, *Holigarna Grahamii* Hook. f.
- Seedling mangoes grafted on *Anacardium occidentale* L. (Cashew) in Martinique were reported to produce fruit double the size, free from fibre and with seed so small that it is unable to germinate.
- Topworking*. The main branches are pruned back to within a foot or so of the main trunk, a few weaker branches being sometimes temporarily left to provide shade and to ensure the circulation of sap until the new top has formed. The strongest shoots of those that subsequently issue from the cut-back branches are budded as soon as their bark is in fit condition, i.e. as it begins to suberize, and the remainder are eliminated.
- Scions from grafted plants in pots can often be grafted by approach directly on to the prepared stump, giving by this method a strong head in about five months. A clean strip of bark is removed from the tree and into the channel thus formed is fitted the selected scion of the pot plant after a preliminary paring to expose its cambium layer. The graft is kept firmly in place by a zinc or copper nail driven through it into the tree and is sealed with grafting wax. It is, of course, necessary to maintain the pot in juxtaposition to the tree by some means and to keep it watered. The scion is partially severed from its parent plant by a deep cut when the graft is made and is completely removed as union proceeds.
- This method of side approach grafting has the merit that the crown of the tree is not sacrificed in the case of the graft failing to take.
- Topworking by crown grafting is often successful if the operation is done carefully and steps are taken to prevent the grafts from drying out, e.g. by means of paper collars, etc.
- Stock Influence*. 66 This problem is now under investigation notably in Java.
- Cuttings*. 13, 71 The mango is not easily raised from cuttings. Burns in India was unable to induce cuttings to root, but states that in the Bureau of Plant Industry Bulletin 46 (Washington, U.S.A.), p. 13, mention is made of mango cuttings forming callus invariably and of the root, though eventually produced, being usually of a single fibre, small and brittle, rendering the cutting difficult to transplant.
- Etiolation*. 53, 64 In Java young seedling mangoes bent down and covered lightly with soil put out numbers of young shoots from the covered buds. By ring barking the shoots at the base and keeping them covered with earth they have been induced to root, and by this method it is thought vegetative rootstocks may eventually be obtained. Experiments in this method undertaken by the Department of Agriculture, F.M.S., resulted in large gall-like calluses forming above the ring wire but no root formation.
- Marcots*. 13 Burns refers to certain experiments in India. Roots were produced but the subsequent establishment of the plants was slow and uncertain.

Polyembryony in the Mango. 6, 7, 81 Broadly speaking, the choice mangoes of the East Indies and Philippines are polyembryonic, while the Indian varieties are monoembryonic. The polyembryonic types reproduce themselves true from seed to such a remarkable extent that it may be assumed that the fertilized embryo is often absent. Thus it should be possible to produce from polyembryonic varieties seedling trees equal in every respect to their parents, as for instance has been the case for over 100 years with the Jamaican variety No. 11. Experiments in Florida have shown that seedlings from monoembryonic grafted mangoes will often exhibit polyembryony in the first generation. Popenoe quotes the theory put forward by G. L. Chaveaud (*Compt. Rend.*, 114, 1892) that polyembryony is the more primitive state, pointing out in support that the choice varieties of India after centuries of vegetative propagation are monoembryonic while the semi-wild varieties are polyembryonic. From the rootstock point of view polyembryony is likely to be an advantage in any attempt to secure uniform stocks from seed.

MONSTERA DELICIOSA Liebm. (*Araceae*.)

54, 92 The spadix is the part which is eaten. The aroma is said to resemble the pineapple and banana combined. The presence in the pulp of spicules of calcium oxalate cause some discomfort in the throat unless "slowly chewed but quickly swallowed."

Division. 6, 113 The growing stems are cut into lengths containing two or three eyes and root well under shade in a mixture of sand, peat and leaf mould.

MUSA spp. (*Musaceae*.) Banana.

30, 89, 90, Bananas except for breeding purposes are always propagated vegetatively.
115, 116 Propagating material may be as follows:—

Sword Suckers. Sword suckers are growths from the root mat in the stage in which the young leaves are still blade-like and tapered and very narrow for their length. They can be planted with no further treatment beyond cutting back any expanded leaves and the removal of all fibrous roots. They will in this case be four or five feet high.

Heads or Heart Suckers. Heads or heart suckers are suckers which have been cut back to within a few inches of the bulb, the central or heart bud cut out sufficiently to prevent further growth from that source and all buds distributed over the surface of the bulbs removed with the exception of two or three. Fawcett suggests that only the largest and fullest outside bud should be left, but Williams in Queensland advocates leaving two or three equidistant round the butt. These will develop and in due course each bear a good-sized bunch. A cut-back head from which the central growing point has not been removed will probably grow a new bulb on top of the old one, forming a plant which is easily blown over.

Bits. Sections ("bits") of old banana stumps can also be planted, provided they contain one good eye.

Water Suckers. There is a type of sucker which produces broad (as opposed to sword) leaves at a very early age. These are popularly known as water suckers, though there is no similarity between their development and the water suckers or shoots that develop on the main branches of a fruit tree. It is commonly believed that these water suckers produce inferior fruit and are slower to bear than sword suckers. Experiments initiated by the United Fruit Company to test this belief were inconclusive and are continuing, but it appeared that water suckers produced less hands per bunch than sword suckers. It is shown by Skutch that the production of sword or broad leaves is a matter of correlation between the leaves of the sucker and those of the parent plant, and that, once this correlation is

dislocated by such means as removing the leaves of the parent, or severing the connexion between sucker and parent, the sucker will forthwith start to form broad leaves. This accounts for the fact that shoots arising from detached bits or eyes form broad leaves almost from the first. Skutch remarks that the phenomenon is analogous to the suppression of lateral buds by the terminal bud of a twig of a dicotyledonous tree.

*Relative
Value of
Propagating
Material.*

The following conclusions are drawn from experiments conducted by the United Fruit Company to discover the relative value of the different kinds of propagating material. The largest fruit was produced by sword suckers, but they are slow and produce only one plant in the first generation. Heart suckers grew and fruited more quickly than any other type of material. The bunches were smaller than those of sword suckers. Heads from plants that had matured fruit have good bunches but slightly smaller than those from plants which had not yet fruited. Bits of 8 to 10 lbs., the standard weight, followed sword suckers and large heads from plants that had not yet fruited in the number of hands per bunch. Water suckers were scarcely inferior to sword suckers in the number of hands per bunch. Small bits containing one eye gave unfavourable germination and weakly plants. Two and a half pound sections of underground rhizomes which should theoretically contain dormant axillary buds gave very slow germination and were a long time before shooting. These and 1 lb. bits are not recommended. Volunteer plants, i.e. those arising from banana fields that have been cut down for replanting, produce fruit only less quickly than sword suckers, but the percentage of hands per fruit is comparatively low. Provided that rhizome tissue is sufficient, i.e. heads should weigh not less than 15 lbs. and bits not less than 12 lbs., and that the material is not in any way suffering from decay, good results can be expected from all classes of material commonly employed.

NEPHELIUM LAPPACEUM L. (*Sapindaceae*.) Rambutan.

- 63 There are many local varieties, some of which are described by Ochse.
- Budding.* Non-petioled, mature, one-year-old wood, brown-grey in colour. The modified
55, 63, 113 Forkert method is used. The leaves of the selected buds should be cut off a month before use. The petioles will then have dropped by the time the wood is required. Petioled buds are useless. The bud wood is not ready till after the harvest, and as picking usually results in a good deal of bruising of the branches Magielse recommends that wood should be taken from trees which have borne a light crop provided that they are known to be good bearers as a general rule.
- Rootstocks.* Magielse experimented with local Javan varieties as rootstocks. He considers
55 the most efficient stock for general use to be *Rambutan atjeh simatjan*. *Rambutan sinjonja* and *Rambutan sitangkweh* are also useful. The latter of these two has the better root system. Using these three rootstocks at a year old 90-100 per cent. success was achieved. The wood is not in a fit condition for budding till the end of the rainy season. The bark is thin and easily torn and for this reason the work should be done by experienced men. On land which is adequately irrigated budding can be performed equally well in the dry season. At least 30 per cent. of budded plants are lost in transplanting or in basketing. This loss can be reduced by cutting the tap root with a spade a month beforehand, or by sowing the rootstock in its permanent position. In the latter case four to six seeds are sown to a hole and the seedlings budded a year later. In a further six months' time the buddings are sufficiently advanced to enable a selection to be made and the surplus discarded. Planting distance is 36 by 36 ft. The plant holes are 18 inches each way. As a rootstock the variety *Rambutan atjeh lebak-boeloës* was not a success, having a poor root system and being subject to gummosis.

Nephelium mutabile Blume (Pulasan) was also a failure as a stock. The buds grew for a month and then yellowed.

Etiolation.
53, 57

The Agricultural Department, S.S. and F.M.S., have used this method with the rambutan. Plants for layering were obtained by means of marcots which required considerable care to establish. These marcots when subsequently layered produced shoots from the layered branches. To obtain roots it was necessary to ring-wire the bases of these shoots and, if this was not delayed until they had become slightly woody, they died off. There was considerable varietal difference in response to the treatment. Some varieties will root freely, while others produce a large gall-like callus but few roots. Shade proved advantageous. Rooted shoots when planted out grew but poorly.

Marcots.
63

The usual native method of propagation (See *Nephelium mutabile*). Many die on transplanting.

NEPHELIUM LITCHI Camb. Litchi.

Budding.
42

In Hawaii the litchi has been budded on the lungan (*Nephelium longana* Camb. *Euphoria longana* Lam.) but with less success than with grafting. Wester in the Philippines also budded it with success.

Grafting.
80

At the Hawaii Experiment Station, where the propagation of the litchi has been studied with some attention, the side tongue graft has been found to be the most effective grafting method. The success usually attained is some 10-20 per cent. and is stated to be increasing. The litchi has been topworked on the lungan using the bark grafting method. The results after sixteen years are described below under *Rootstocks*.

Inarching.
6

This is occasionally practised and is easily accomplished.

Rootstocks.
37, 42, 80

In Hawaii the most vigorous of a large number of seedlings are selected for rootstocks when a year to eighteen months old. The seeds themselves are only viable a few days and if kept longer require special conditions. In China varietal preferences have been discovered, for instance the mountain variety Shan Chih has proved particularly successful as a stock for the small seeded variety No Mi Chih. The litchi is a water-loving plant and in order to extend the range of cultivation to situations where the water supply is less abundant a drought-resistant stock is essential. Groff considered that this may be found in *Litchi philippinensis* Radlk., the wild litchi of the Philippines, a tall large-seeded tree inhabiting well-drained uplands.

The lungan (*Nephelium longana* Camb.) will unite easily with the litchi, and its effect as a stock is to produce for a time a growth very much more rapid than does the litchi on its own roots. The character of the scion foliage also appears to change. The unions, however, do not appear to be permanent and in a few months the scions have died. In a letter (1934) Mr. W. T. Pope, the Senior Horticulturist of the Hawaii Experiment Station, states that two of the lungan trees topworked with litchi scions by Professor Higgins about 1917 are still living but do not fruit and are far from vigorous. Other rootstocks suggested for trial are *Pseudonephelium fumatum* (Blanco) Radlk., from the Philippines, Borneo and Perak. The various species of *Euphoria*, especially *Euphoria cinerea* Radlk., should not be neglected.

Cuttings.
6, 37

The litchi has been rooted from softwood cuttings in a medium consisting of two parts sand, one part loam. Up to 80 per cent. success can be expected under suitable conditions. Bottom heat is necessary or at least gives a considerably increased chance of success. The most easily rooted cuttings are those which

are allowed to retain most of their foliage and are taken about three to four inches long from the tips of the young shoots.

Layers.
6

Layering can be done by suspending flats covered with soil on a pole framework among the extremities of the branches. These are notched and fastened down on the flats and covered with soil which must be kept moist.

Marcots.
42

This is the usual method by which the litchi is propagated especially in China. A labour- and time-saving method of marcotting was evolved in the Hawaii Experiment Station in 1917 whereby several could be rooted at the same time in one trough-shaped box. The branches used with this box must be small (half-inch diameter). They are passed into the box through notches cut in the side. Root damage, when the time comes for separating the rooted plants, is avoided by washing out the soil with a stream of water.

NEPHELIUM LONGANA (Camb.). Lungan.

37, 112

The lungan can be propagated by the same methods as the litchi.

In the Kwangtung district of China, where it is very largely grown, the trees are usually seedlings or inarchings. When inarched the rootstock is almost invariably the variety known as Wu yuan. The union is made four feet from the ground, the rootstock being then five or six feet high and from three to five years old. This high inarch saves the trouble of raising the rootstock to a level with the branches of the parent tree as would be necessary with a lower union or shorter stock. Trees thus treated, however, for many years after require to be protected from breakage with bamboo bracing at the union.

Wu Ying Kuei in his monograph on the litchi and lungan refers to a method of grafting the lungan, whereby three or four grafts of the same rootstock variety are sandwiched between the rootstock and the top. "This sandwiching of grafts consists of topworking the lungan on the lungan, but as soon as the scion is well established it is cut off and a new graft inserted in the new growth of wood. This process is continued three or four times." The Chinese say that this method produces large sweet fruit, and that resistance to typhoon winds is much increased, since the assemblage of grafts provide a brace that cannot readily be torn out.

NEPHELIUM MUTABILE Blume. Pulasan (Malaya).

63

There is a number of local varieties ; in Java it is considered with the rambutan to be one of the best fruits.

Budding.
55

Non-petioled mature one-year-old bud wood. Modified Forkert method.

Rootstocks.
55, 63

Magielse used as rootstocks the local Javan forms *Kapulasan seebabat* and *Kapulasan merah* (red) and obtained 90 per cent. success during the wet season. Budding cannot take place, according to Ochse, immediately after the harvest, as the bud wood is then too dry. The stocks do not transplant well, so that it is advisable to sow the seed which is to furnish the rootstock in its permanent position, a suitable spacing being 24-30 feet square. Buds of *N. mutabile* failed to take on *N. lappaceum*, the rambutan.

Marcots.
63

This method is mainly used by native growers. The same difficulty of transplanting occurs as with budded plants. To reduce mortality the newly-rooted marcots are usually removed and grown on under shade for a year before transplantation to their permanent quarters.

Etiolation.
53, 57

The method is the same as for *N. lappaceum*. In experiments in Malaya some shoots rooted when ringwired, though slowly, but died on removal to bamboo pots. In another district when the shoots were ring barked at the base instead of wired, rooted shoots were obtained in from eight to twelve weeks from the time of

ringing. The best results were obtained with shoots that were not earthed up until they were a foot high. Shade in dry weather was helpful. The results of potting the rooted shoots in this second experiment are not known to us.

OLEA EUROPAEA L. (*Oleaceae.*) Olive.

- Budding.*
8 The buds should be well formed and taken from fresh wood.
- Grafting.*
8 Rind or crown grafting or some method by which the stock is not split are the most successful. The scions should be of fresh wood about quarter-inch in diameter and possess well-formed buds. Experiments in U.S.A. showed best results (76.6 per cent.) when the grafts were tied with cotton string and covered with moist soil to the top of the scion. Grafts tied with raffia, waxed and covered with soil to just above the union gave 24.7 per cent.
- Rootstocks.*
8, 14 A rapid method of raising seedling rootstocks is as follows. Perfectly ripe fruit is gathered and the pulp removed by preliminary immersion in a 3 or 4 per cent. soda lye for several hours, followed by rubbing through a three-sixteenth inch mesh wire sieve. The cleaned seed is placed in 25 per cent. brine solution (two pounds common salt to one gallon water) and all floating seed discarded. The salt is removed by washing in fresh water before planting. The apex of the seed is then clipped off. A suitable instrument can be improvised out of a pair of farrier's clippers, mounted in such a manner that one arm is fixed while the other is operated by an attached wire controlled by the worker's foot. A spring between the handles ensures that the jaws automatically reopen. Up to 1,500 seeds an hour can be clipped by this machine. The clipped seed is sown about quarter-inch deep in trays containing a compost of sand three parts and leaf mould one part, and covered with a shallow layer of moss or similar moisture-holding material. Warmth will ensure rapid germination, which should begin in about five weeks and continue for two or three months. The seedlings are potted when five inches high and kept in a protected place until spring when they are planted in nursery beds. The following autumn and spring they can be budded or grafted. A whole year is thus gained over the usual method which requires preliminary stratification of the seed for sixteen months. In Italy recently the common lilac used as a stock has induced fruiting of the olive scion in the second year after budding.
- Cuttings.*
6 Cuttings taken from any part of the tree when it is most dormant, but preferably mature terminal shoots cut four or five inches long, can be rooted in sand under glass. If glass is not available, cuttings of older wood $\frac{3}{4}$ to $1\frac{1}{2}$ inches in diameter and 14 inches long can be rooted in the open. The ends of these cuttings should be split or the bottom two or three inches scratched with a knife. A method used in Spain is to bury large branches cut into lengths and incised to half their diameter every three or four inches, in trenches about ten inches deep. Rooted shoots arise near the saw cuts and when sufficiently developed they are cut off and planted out.
- Root Suckers.*
6 Suckers taken from the base of the tree and having a portion of the old wood attached root easily.
- Ovuli.*
32 These are the rounded growths at the base of the tree, varying in size from a walnut to a large orange. They contain white parenchymatous tissue rich in nutrients and possess dormant buds. Those which are smooth barked are cut off in winter, the large ones divided again into sections each containing an eye, stratified in sand till March and then planted three or four inches deep in sunny nursery beds, which have been prepared and well manured during the winter. The beds are later covered with trash to conserve the moisture. Shoots will appear in two or three months. The plants remain in these beds four years or

five years, during which time they are trained to a single stem and are then set out in their permanent positions. It is claimed that by this method better plants are produced than from seeds or cuttings.

PANGIUM EDULE Reinw. (*Bixaceae*.)

Budding. Non-petioled wood, fairly mature, turning from bright green to bronze green.

54, 92, 113

Rootstock. Age of stock at point of insertion of bud unimportant.

113

54 **PASSIFLORA.** (*Passifloraceae*.) Passion Flower.

Cuttings— The various species can all be propagated without difficulty by cuttings six to eight inches long taken from matured shoots and inserted in sand or sandy soil.

Layers.

81

They can also be layered.

PASSIFLORA LAURIFOLIA L. Water Lemon.

Grafting. Can be cleft grafted.

113

Rootstocks. The granadilla (*P. edulis* Sims) is reported to be a good stock for *P. laurifolia* and probably for other varieties also.

113

PERSEA GRATISSIMA Gaertn. (*Lauraceae*.) Avocado.

Care must be used in the selection of bud or scion wood, the avocado being subject to bud variation.

Budding.

27, 45, 55,

81, 96,

118, 121

Given proper care and experienced workers the avocado can be shield budded with a high percentage of success. The most satisfactory buds are those selected from well-matured terminal growth which is on the point of starting a new flush. It is usually six to eight weeks old. The buds should be plump and should not have started into growth, though the terminal bud on the twig may have done so. The buds in the middle of the twig are usually the most successful. The wood should be in a condition in which it will bend easily without breaking. The shield is cut one to one and a half inches long, a portion of the wood being left on behind the bud. It must be smoothly cut, the closest contact between cambium of bud and stock being most necessary. The bud must be inserted immediately after being cut or it will dry out and fail and the bud wood, after its removal from the tree, should be kept moist in damp moss or oiled paper until used. The tie may be of waxed cloth or raffia and should not be removed for six to eight weeks when the bark flaps will have healed, though the bud will have united with the scion in three weeks. The stock is pinched back at this time to encourage the bud to shoot, and a few weeks later it is cut back to the union and waxed over. A small piece of the leaf petiole is often left on the bud. The bud is inserted a few inches above ground level. Growers in California claim better results if the leaves subtending the buds to be used are cut back, removed, or have their stalks broken a few weeks before use.

In California bud wood stored for a month or six weeks in moist but not wet sphagnum moss, sawdust, or sand is considered to possess advantages over fresh wood. During this storage period over-developed and therefore unsuitable buds absciss, and bud wood generally becomes less tender and requires less care in handling.

Patch buds are sometimes used when the stock stems are thick. In experiments in Java 80 per cent. success was obtained using the Forkert method and non-petioled bud wood during the rainy season. Buds taken from two- and three-year-old wood proved less successful than buds from year-old wood.

82

Embryo Budding. A special budding method designed to obtain earlier indication of the results of seed selection may be of interest. It is known locally in California as Rideout's method. When the rootlet of the germinated seed is one inch long, a half of it is removed longitudinally by a cut from the base of the shoot to the root tip. One of the cotyledons is also removed. The second cotyledon is left in place or may be cut away, in which case a small portion is left to assist in forcing the rootlet into the incision. The prepared seedlings are inserted by means of T-shaped incisions into mature trees or nursery stocks and are forced well down until the radicle is firmly in place. The tie is made with one-eighth inch wide strips of budding rubber and the whole is covered with dental sheet rubber to prevent drying out. (See also *Fractional Embryos* below.)

Grafting.

26, 43, 79,
94, 102,
119

In Florida during the last few years grafting has largely superseded budding. The reasons given are—that a tree of planting size can be produced in less time, that varieties difficult to bud are easily grafted, that it is easier to obtain suitable graft scions than suitable bud wood, and that the buds are less liable to be shed. The chief methods used are whip grafting on stocks of pencil thickness or side grafting, if the stocks are more slender. The scions are terminal shoots two to two and a half inches long taken from the last matured growth just as it begins to flush. In St. Lucia, B.W.I., wedge grafting at an early age on potted plants is practised in the following manner. Seedlings two weeks old produce a soft, dull red, watery plumule six to eight inches long furnished with scale-like leaves and composed of meristematic tissue. The top is cut off five inches from the ground and the remaining portion split to the depth of one inch. Into this cleft is inserted firmly a tapered soft shoot of the scion variety, from which flower-buds and leaves have been removed. The graft is tied with raffia, watered and placed in the cool. After five days the raffia may be gradually loosened. A watering of sulphate of ammonia and later a top dressing of complete manure is given to stimulate the growth. Losses by this method are negligible. In another somewhat similar method the scion is applied to the side of the plumule, a cut one inch long down the side being made to receive it. In this case the top of the plumule is not cut off till union has taken place. Wedge grafting with older plants in beds is successful if light shade is available and growth conditions good. In St. Lucia seedlings of special varieties raised from imported seeds were beheaded and grafted with the mature wood of a local variety on which was reimposed the apical shoot of the beheaded plant. The purpose was to hasten if possible the fruiting of the imported seed plant.

Rootstocks.

45, 55, 63,
81, 96, 121

Information on rootstock effect is still meagre. There are three main types used as stocks, all being grown from seed. The West Indian type is vigorous but very susceptible to frost. The Guatemalan is vigorous and thrifty, somewhat tender but less so than the West Indian. The Mexican type, the hardiest of the three, is generally vigorous but shows a wider range of variability. Guatemalan stocks and scions appear to be compatible with the other two races. West Indian buds are less successful on Mexican stock. A stock now much used in California is Fuerte, apparently a natural hybrid between the Guatemalan and Mexican races, displaying great vigour and considerable uniformity. The stocks for budding should be small and vigorous and be kept in rapid growth until required, otherwise the wood hardens, sap is deficient and the bud may be difficult to force into growth. Popenoe considers that many failures are due to neglect of this point. Some workers consider that opening the bark with the ivory of the budding knife injures the tissues and that the bark should be in such a condition that the bud can be forced into the cut by light pressure without loosening the skin with the knife. The stock must not be cut back too close to the bud in the first instance as the stub is usually required as a support to which the growing shoot can be tied.

Rootstocks raised in pots are apt to become pot-bound if not carefully watched. This retards their subsequent growth. In Java the practice is to cut back the stock to within one foot of the bud immediately after budding. It is said that, if the stock, before union is complete, is headed nearer the bud than this, it may die back below the bud. Attempts to bud on to *Litsea sebifera* Blume failed. *Fractional Embryos*. Two or four presumably identical rootstocks can be obtained by planting fractional embryos. These are obtained by breaking apart the two cotyledons of the seed. A fraction of meristematic tissue will adhere to each, though possibly not in equal quantity. These cotyledons may be bisected, and so long as some meristematic tissue, however small, is left on each it will grow and thus four plants may be produced from a single seed. The process might be repeated still further, but plants from eighth embryos are usually inferior or backward. Fractional embryos appear to develop less quickly than whole embryos as regards stem diameter and total height, but their root development does not markedly differ.

Plants thus sprouted can also be used for budding on to grown trees (see *Embryo budding*) with the additional advantage that in the event of failure specimens of the variate will still be available. These fractional embryos can also be grafted as stocks before development. The scion two to five inches long is wedge grafted into the meristematic tissue of the fractional embryo at a point where it unites with the cotyledon. The embryo may be dormant or sprouting. If sprouting and the plumule is about one inch long, it is cut back before grafting to the point of its union with the cotyledon. Occasionally the whole embryo is first sprouted and then before grafting divided lengthwise into equal parts including the root. If these embryo grafts are planted too deeply, scion rooting may occur.

Topworking. In U.S.A. a method of cleft grafting is used for converting unprofitable trees. 27, 45, 58, The tree is cut back to from one to four feet above the ground, depending on the diameter of the trunk, or the scions may be inserted on headed-back main branches, 81, 96, 104, if these exceed three inches in diameter. The scions three-eighths inch in diameter are cut six to eight inches long, and are of older wood than is used for budding, being usually taken from the second or third flush back from the tip. Nurse limbs which are sometimes left do not appear to be essential. Two scions are placed in each cleft which is kept open with a hardwood wedge. With small stocks the wedge is withdrawn completely when the scions are in place, but with large stumps this will result in injury to the scions from pressure, and in these cases the wedge is only withdrawn sufficiently to ensure a firm grip. A collar of paper projecting above the scions is placed round the upper part of the stump and filled with a mixture of sand and peat moss which is kept moist. The top of the paper cylinder is bent over to form a cap and holes are made at the top and bottom of the cylinder for ventilation. If two scions to a branch are used and both succeed, the weaker can subsequently be removed. Avocado wood is of a brittle nature, and, to avoid splitting, branches to be grafted should first be sawn off a foot above the point where the graft is to be made. A recent modification of cleft grafting, for which extraordinarily successful results are claimed in California, consists in notching the stubs with a saw instead of splitting them and driving in large, short, scion wood cut to fit exactly and having only one or two buds. The cut surfaces are waxed in the usual way, protected with sacks and the trunk and branches whitewashed. The most successful time for both these operations (in California and Florida) is in January and February when sap flow is slow and the bark does not slip. In cleft grafting, should the scions fail, selected shoots arising from the cut ends of the branches can be budded in June or July. The shoots arising from the upper side of the stubs will form stronger unions than those on the under side. They will require support against breakage for one or two

seasons. Buds can also be shield budded direct on to the stem or main limbs, if sap is flowing freely. In this method the tie should be left on for two months, as the bark on large trees has a tendency to lift. Sucker buds must be removed as they form. With direct budding nurse branches are left on the tree temporarily. Topworking can also be achieved by rind grafting and a form of side grafting. In the latter case a T incision is made in the side of the trunk or branch, the scions, of well-matured wood, made with a long sloping cut on one side only, are pushed into the incision as in shield budding. The branches are not cut back till the scions have grown. The easy lifting of the bark is necessary for the success of these methods. All varieties of avocado do not respond equally well to topworking.

Bottle grafting has been used in St. Lucia with success when converting seedling trees. This is a form of grafting in which the scions are stood in water in bottles or test tubes attached to the tree and grafted by approach at suitable points.

Cuttings.
99

Extensive experiments into the rooting of avocado cuttings carried out in Florida in 1933 failed to produce any results beyond callusing.

Marcotting.
87

Some difficulty is found in getting the avocado to root from marcots. Experiments have shown that their failure to root is due to the very rapid callusing over of the ringed portion, even when this is as wide as two inches. The callus will be found to contain protuberances which are in fact rudimentary roots. If the marcot is ringed a second time just below the callus and the rooting medium replaced, these roots will grow out within a short time and the plant will be established.

Etiolation.
53

The Department of Agriculture, Malaya, are experimenting with this method. The laid-down branches produce shoots freely, but ring wiring appears to be necessary to obtain root formation, which even then is slow. The growth of rooted shoots has been less satisfactory than that of budded plants. This slower growth of "own root" vegetatively raised plants is, however, a fairly common phenomenon in their early years.

PHOENIX DACTYLIFERA. (*Palmaceae*.) Date Palm.

Offshoots.

I, II, 22,
24, 25, 59,
61, 93

The date palm can only be propagated vegetatively by means of offshoots which are produced in greater or less numbers according to variety, usually at the base but occasionally some way up the trunk. Production is also influenced by the water supply. This method of propagation is the only one used in commerce. Details of treatment of offshoots vary in different countries. In Arizona and elsewhere exhaustive experiments were started which have resulted in the evolution of a technique that, if carefully followed, renders a very large measure of success certain. The most important principle involved is that the offshoots should be rooted before their removal from the parent plant. Occasionally this is accomplished in the natural course of development. Usually, however, it will be found necessary to mound up the soil round the base of the group of offshoots to the depth at which the plant will subsequently be placed in the soil. In the case of offshoots which are placed above ground level a box to contain a foot deep of soil may be built round them. Dry or old leaf bases should be cut away so that direct contact between soil and base of shoot is assured. The rooting surface is that part of the offshoot bulb which is furthest from the parent plant. A suitable soil mixture for the boxes, which, while retentive of moisture, will ensure free drainage and remain on the roots during transplantation, is one part medium heavy soil, one part sand and one part stable manure. This soil and also that of the mounds should be kept moist at all times. A period of ten months to a year is necessary for boxed or mounded plants to acquire a satisfactory root system. If the offshoots are thickly clustered, it is usual to tie

back the leaves a month or so before cutting in order to allow the sunlight to reach and harden the base of the sucker. The time of year most suitable for removing and planting the offshoots varies with each date-growing country, but a relatively low temperature, moist atmosphere and plentiful water are desirable. These conditions often prevail in the spring, and in Egypt also with the rise of the Nile in August or September. In Egypt and the Sudan the date offshoot is sometimes induced to form roots after cutting, but before planting, by being wrapped (up to as many as twenty-five in a bundle) in date fibre and old sacking and stood in water. The time required for root production is three or four months. Each date-growing country has its own types of tools for removing the offsets from the parent tree, but undoubtedly the most efficient both for ease of manipulation and a reduced liability to cause damage is that devised in the United States. This consists of a rectangular steel chisel with a blade four and a half inches wide, flat on one side, with the reverse side bevelled towards its sides and base to form three sharp cutting edges. This bevelled edge is placed against the palm, the flat side being against the offshoot. The handle of the chisel must be strong to withstand the heavy blows of the eight to ten pound sledge hammer used in driving the chisel and the stress and strain of withdrawal, which is necessary when the chisel has to be reset in the cut. Crider remarks that the operation of cutting offshoots requires skill, patience and good judgment and is not to be trusted to an amateur. The medium-sized offshoot weighing ten to fifteen pounds has hitherto been considered the most suitable size, but opinion is now not altogether unfavourable to the heavier shoots. The following measurements are useful in determining the weights: an offshoot with a greatest bulb diameter of 5 to 6 inches will weigh 10 to 15 lbs.; 6 inches, 15 to 30 lbs.; 10 to 14 inches, 50 to 75 lbs. To lessen transpiration it is usual to trim the foliage of the offshoots just before or just after their removal from the tree. This operation consists in trimming off the lower leaves, leaving stubs sufficiently high to protect the inside or crown leaves, and cutting the remaining leaves square across, eighteen to twenty-four inches from the crown. Too close pruning is as bad as too little. A removal of two-thirds of the leaf surface is a proper proportion for well-rooted plants. When offshoots are to be planted immediately, further protection to the roots is not necessary. If the offshoots are to be shipped or otherwise delayed, the ball of soil should be wrapped in burlap and kept moist or in wet sphagnum moss. Care in handling the offshoots is very necessary. A sudden jar may injure, and handling by the inner leaves may result in their being pulled out or broken, with damage to the terminal bud. Unrooted offshoots may also be used, but the percentage of success is very much lower. Unrooted offshoots are planted in canvas propagating sheds so constructed that air currents are eliminated and a warm moist atmosphere is maintained. The ground in these frames is prepared by excavating ten to twelve inches of the surface soil and replacing it with fresh stable manure well packed, re-covering with two inches of soil and flooding the bed till the manure is thoroughly soaked. After four to six days the bed is flooded again and the offshoots can then be set. The maintenance of a high humidity until rooting takes place is, under this system, considered essential. New growth may start immediately, or the plants may even lie dormant for three or four years and then begin to grow rapidly. The plants may be removed to the field when they have made the second group of leaves. (Leaves appear in groups of three.) Unrooted offshoots after removal from the tree require to be seasoned to reduce the chance of fermentation. This is accomplished by leaving them on the ground under the tree or setting them up in groups of fifteen to twenty in an open place where the air will circulate freely. The time taken is from ten to fifteen days according to weight. In connexion with the planting of unrooted shoots, experiments in Arizona seemed to show

that compared with the canvas structure offshoots rooted better when placed directly in the field, and that, if the canvas structure was used, a relatively cool atmosphere with moderate humidity was better than a hot one with high humidity. Brown mentions that small offshoots can be rooted by planting them in beds of soil with hot water pipes below.

PHYLLANTHUS ACIDUS Skeels. (*Euphorbiaceae*.) West India Gooseberry.

Budding. The buds should be cut large from non-petioled, fairly mature, greenish brown, smooth, slender wood.

113

Rootstocks. Own species. The age of stock at point of insertion of the bud is not important.

113

PHYLLANTHUS EMBLICA L.

Budding. Mature petioled bud wood, greenish brown in colour.

113

Rootstocks. The age of stock at point of insertion of bud is unimportant.

113

PITHECOLOBIUM DULCE Benth. (*Leguminosae*.) Manila Tamarind.

Budding. Use barely matured, petioled bud wood.

113

Rootstocks. Own species. Age of stock at point of insertion is unimportant.

113

PSIDIUM GUAJAVA L. (*Myrtaceae*.) Guava.

Budding. Shield, patch and modified Forkert methods are successful, using non-petioled bud wood so far mature that the green shall just have disappeared from the stalk. In Java 100 per cent. success was obtained during the wet and the dry seasons. In California and Florida from November to April is the best time.

55, 18

Grafting. The approach method is used in India.

16

Rootstocks. Seedling stocks of the same species. According to Popenoe, if shield budding is used, these should be worked as soon as they are large enough. On older stocks patch budding or modified Forkert is better. The stocks used in the Java experiments were thirteen months old. The bark is very thin and budding should be entrusted only to experienced workers. Stocks should be budded near the ground, as otherwise they send out stem shoots very persistently.

55

Root Suckers. These can be obtained by severing or wounding lateral roots at a distance of two or three feet from the tree. Buds will appear at the wounded parts and these can later be transplanted. This is the most rapid way of producing clonal plants on their own roots.

16, 81

Cuttings. Half-ripened wood will strike. If bottom heat is available, it should be used. Other varieties of guava can be propagated in the same way.

16, 81

Etiolation. Shoots root easily when ring wired and can be established in bamboo pots without much difficulty.

53

PUNICA GRANATUM L. (*Punicaceae*.) Pomegranate.

Cuttings. Usually propagated by hardwood cuttings of dormant wood taken from shoots or suckers. The cuttings are ten to twelve inches long and are, in California, planted in early spring in the ground eight to ten inches apart with three feet between the row, the entire length of the cutting being buried with the exception of one eye. In Palestine two eyes are left above ground, but these are often protected from the sun by a light covering of loose earth. A light sandy soil is the most suitable. Cuttings stratified in sand from the previous autumn callus

36

over during the winter and probably root earlier. In Palestine the cutting is sometimes bent before planting to hasten rooting, but it seldom presents any difficulty in this respect.

Other
Methods.

In Java the pomegranate is also propagated by root suckers and marcots.

63

ROLLINIA DELICIOSA Saff. (*Annonaceae*.)

Budding. Use well-matured, year-old bud wood.

113

Rootstocks. Congenial stocks are *Annona glabra* L., *A. muricata* L., *A. reticulata* L.

113

This species is often referred to as *R. orthopetala* A. DC. It is, however, easily distinguished from that inferior species by its widely spreading decurved corolla wings.

SANDORICUM KOETJAPE (Burm. f.) Merr. (*Meliaceae*.) Santol.

Budding. The bud wood should be unpetioled, fairly mature, turning brown or grey and rough, rather slender. In experiments in Java 60 per cent. success was obtained during both dry and wet seasons using the modified Forkert method. In recent experiments in the Philippines (1934) shield budding on young seedling stock was not very successful, but Wester some years earlier succeeded well with this method on somewhat older stocks, cutting the buds about one inch long and inserting them on the stocks where it had the same age and appearance as the scion wood.

Grafting. Cleft grafting on young seedling stocks was successful.

33

Rootstocks. Its own species was used by all experimenters so far as can be ascertained. A suitable age for the stocks is eleven to twelve months.

Topworking. Undesirable trees can be successfully cut back and rind grafted. The worked trees should be given some protection against sunscald until the new top has developed sufficiently to shade the trunk.

33

SARCOCEPHALUS ESCULENTUS Atzel. (*Rubiaceae*.) Sierra Leone Peach.

A common West African tree having deep red edible fruit, the size of a man's fist. The wood is much used for inlaying.

Budding. Wester merely remarks "easily budded".

113

Cuttings. Well-matured hardwood cuttings about twelve inches long inserted to three-quarters their length in sandy soil during the dry season.

113

SPONDIAS CYTHEREA Sonn. (*Anacardiaceae*.) (Syn. *Spondias dulcis* Forst.) Hog Plum, or Jew Plum (West Indies), Otaheite Apple (Straits), Ambarella (Ceylon).

The fruits have a sub-acid flavour somewhat resembling that of the apple.

Budding. Non-petioled, slender, mature but green and smooth bud wood. The bud should be cut with an ample wood shield $1\frac{1}{2}$ inches long and should be inserted in the stock at a point where it is approximately of the same age and appearance as the scion.

113

Grafting. With this variety cleft grafting may give better results than budding, at any rate when its own species is the stock.

112

Rootstocks. Own species and a local variety known in Java as *Kedongdong manggasari*. Magielse in his experiments obtained 90 per cent. success with this latter stock,

31, 55

and only 45 per cent. when budded on its own species. Both stocks succeeded best at ten months old. If budded earlier, stock growth is still rapid and the quickly increasing girth may cause the bud ties to cut into the bark. Buds on *Mangifera caesia* Jack and on *Dracontomelon mangiferum* Blume failed. Firmininger states that plants are usually obtained by grafting on seedlings of *Spondias mangifera* Willd. (*S. pinnata* Kurz.).

Cuttings. Cuttings of all sizes root easily, including large wood of a size suitable for fencing.
6, 113

SPONDIAS LUTEA L. Hog Plum. Yellow Mombin.

- 6, 81 The fruits have usually a rank pungent flavour, but there are varieties that are sweet and agreeable.
- Budding.* Use slender, smooth, glaucous, non-petioled, mature bud wood ; cut the bud with
113 large ample wood shield about one and a half inches long ; insert the bud in the stock at point of same age and appearance as scion. It is inclined to bleed badly.
- Stem* Mature wood cuttings of any size root easily.
Cuttings.
81

SPONDIAS MOMBIN L. (Syn. *Spondias purpurea* L.) Red Mombin. Spanish Plum. Ciruela.

- 81 Popenoe considers it capable of great improvement by selection and vegetative propagation since it occurs in a wide range of seedling races or forms.
- Grafting.* Easily cleft grafted. The scions should be three to three and a half inches long
113 of unpitioled wood of the previous year from which the green colour has disappeared.
- Rootstock.* It grows well on *Spondias mangifera* Willd. (*S. pinnata* Kurz.). The graft
112 should be inserted about three inches above the ground and the stock at point of union should not exceed three quarters of an inch.
- Cuttings.* Wood of every size roots so easily that other forms of vegetative propagation are
81, 113 not much used. During the rainy season cuttings twenty to thirty inches long may be planted twelve inches deep in their permanent positions. Plant distance is twenty to twenty-five feet apart.

SPONDIAS PINNATA Kurz. (Syn. *S. mangifera* Willd.) Hog Plum or Amra of India.

- Rootstock.* This species is often recommended as a rootstock for other varieties.
31, 113

SPONDIAS TUBEROSA Arruda. Imbu.

- 81 Comparatively little known but perhaps the best of the *Spondias* spp. It is worth cultivating and yields heavily. The flesh is soft and melting with a faint flavour of orange.
- Grafting.* Use non-petioled scions about three to four inches long of the previous season's
112 wood from which the green has disappeared.
- Rootstock.* The stock should be not more than three-quarters of an inch in diameter at the
112 point of union which should be about four inches above ground. *Spondias pinnata* Kurz makes a good rootstock. Failure resulted when *S. cytherea* Sonn. was used.

Cuttings. Like other members of the genus it grows readily from cuttings.
112

TAMARINDUS INDICA L. (*Leguminosae.*) Tamarind.

Budding. Petioled, well-matured, brownish or greyish bud wood.
113

Rootstocks. Age of bud at point of insertion of stock unimportant.
113

Etiolation. Rooted shoots were obtained in Malaya from ring-wired seedling plants, but died later. Rooting formation was slow and the method is not considered promising.
53

TERMINALIA CATAPPA L. (*Combretaceae.*) Tropical Almond.

6, 31 A nut having a fine filbert-like flavour with a crispness like that of a fresh walnut.
Budding. Shield budding is successful.

Rootstock. Own species. It can also be easily budded on *T. edulis* Blanco.
12

TERMINALIA EDULIS Blanco.

12 The small, smooth, fleshy, dark-red fruits are pleasantly acid and make a good preserve.

Budding. Shield budding, using petioled, fairly mature, brownish or greyish green bud wood.
113

Rootstock. On own species. The age of stock at point of insertion is immaterial.
113

ZIZYPHUS spp. (*Rhamnaceae.*) Jujube.

97 Cultivated jujubes appear to belong to two species which, however, show little difference. The Chinese jujube is considered to be *Z. Jujuba* Lam., and *Z. mauritiana* Lam. is the Indian form. Although many poor seedling forms exist, many of the large fruited Chinese varieties are excellent, both for eating out of hand and preserved.

Budding. This is best done in spring. The hardness of the bark and the thinness of the wood make budding difficult. The bud is easily damaged when being cut owing to the angular shape of the wood. A cut both from above and below when removing the bud will facilitate the operation. Twig budding is sometimes successful.
97

Grafting. The Chinese varieties in California are propagated best by whip grafting. The wood should be of the previous season's growth, of pencil thickness. Wedge grafting may be used if the stock is much larger than the scion. Growth is usually rapid.
81, 97

81, 97 *Bench Grafting* is useful when the weather is unsuitable for outside work. The stock plants are cut off just above the root or the larger roots themselves may be used. They are then wedge or whip grafted with scions about four inches long, packed in damp sawdust and kept in a temperature of 40-50 degrees for a month, by which time a callus will have formed and the plant may be put out in the field. Young transplanted bench grafted plants should be entirely covered with heaped-up soil when first set out, any drying out being fatal. Scions may, in California, be cut after the first of December and stored. Grafting may be done in February and March.

- Rootstocks.* 97 Seedling rootstocks are used. The plants resent disturbance, hence field grafting on two-year-old roots is often practised. This is done at ground level and earth afterwards is drawn over the scion to one inch above its extremity. The best time for field grafting is as soon as the stocks become full of sap and begin to grow.
- Stem Cuttings.* 97 Stem cuttings are seldom successfully rooted, though scion rooting sometimes occurs.
- Root Cuttings.* 97 This form of cutting may often be used with success. Pieces of root four to six inches in length with a diameter of not less than three-sixteenths of an inch have made graftable plants the first season. The ends of the roots of the stocks used for bench grafting are often employed in this way.

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